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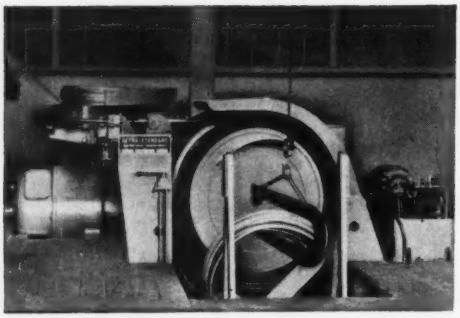

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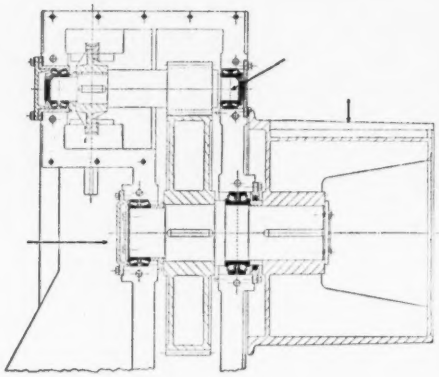

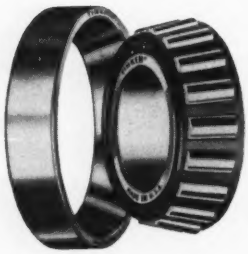

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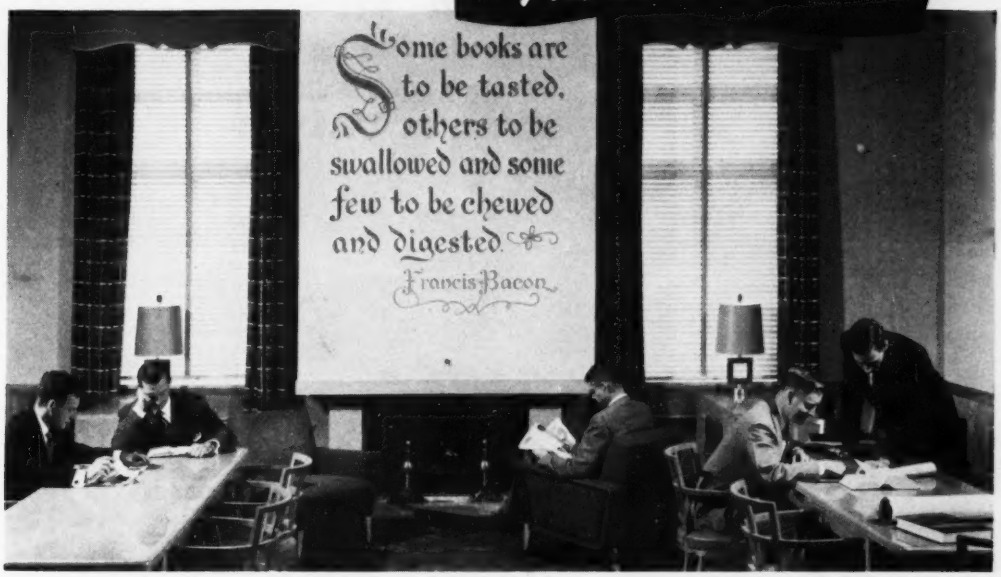

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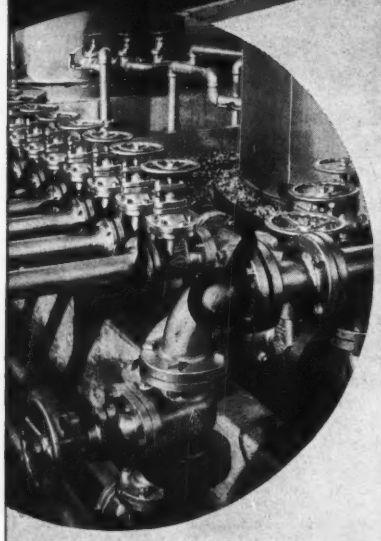

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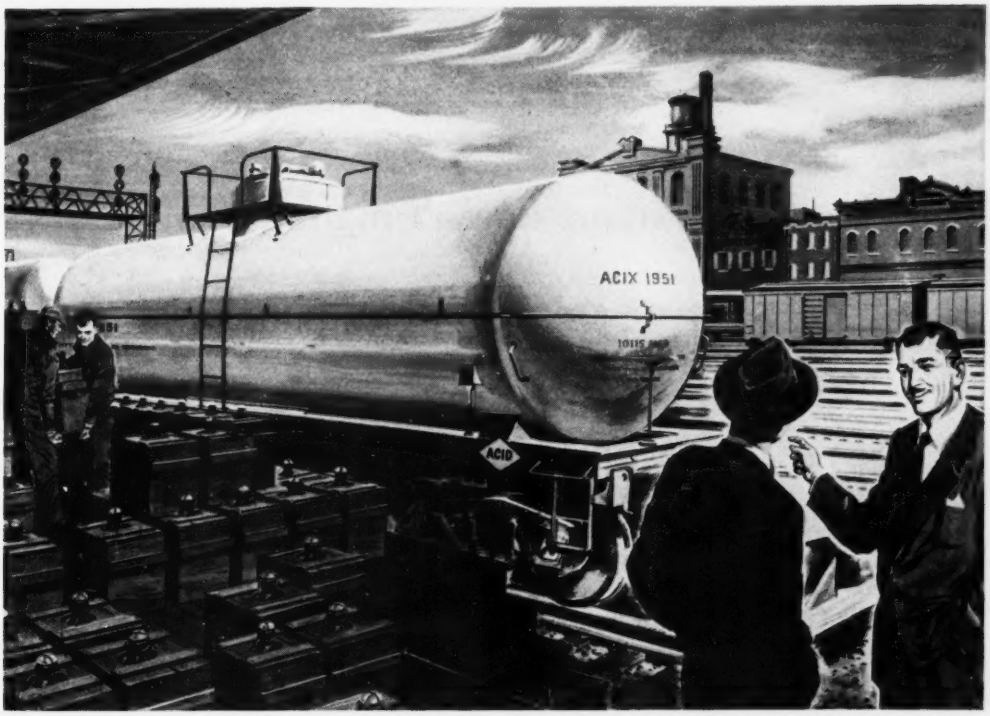

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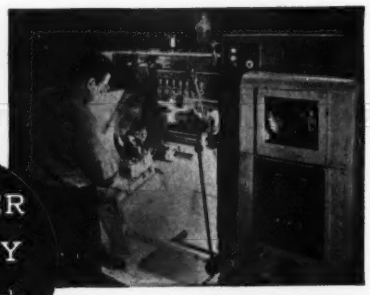

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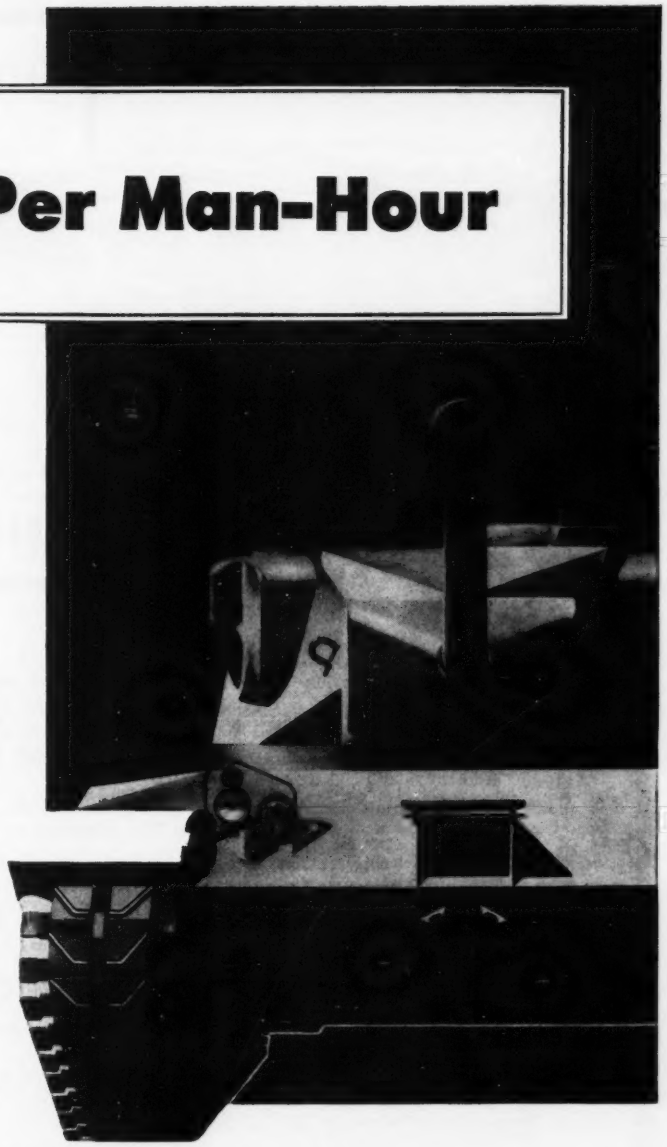

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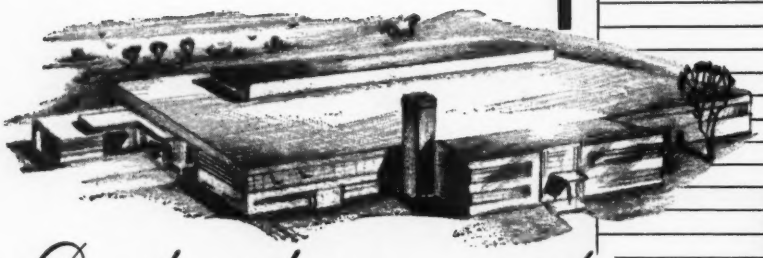

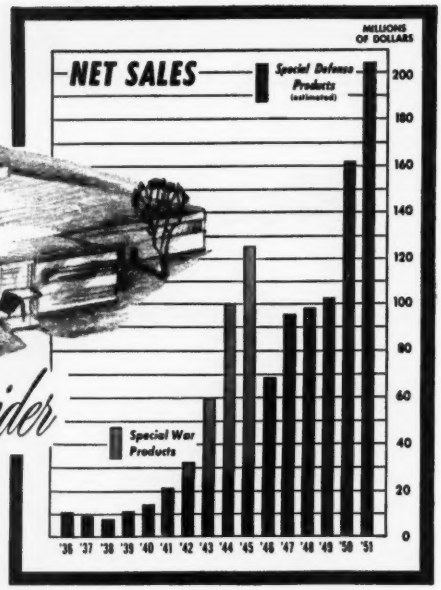

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METAL TRANSFER IN ARC WELDING 9
by Paul J. Wisniewski, MetE '53 and David A. Thomas, MetE '53
LOUDSPEAKER ENCLOSURES 12
by Peter H. Pincoffs, EE '52
ELECTROPLATING—SCIENCE AND INDUSTRY 15
by Edward Leventhal, EP '56
INDUSTRIAL AIR POLLUTION 17
by Ian J. Marwick, EE '53
FACULTY PROFILE—PROFESSOR THOMAS J. BAIRD 19
by David Scheraga, ME '54
PRESIDENT'S MESSAGE 20
ALUMNI NEWS 21
NEWS OF THE COLLEGE 22
RETIRING BOARD OF THE CORNELL ENGINEER 24
EDUCATION FOR COLLEGE—TAU BETA PI ESSAY 25
by Paul Szasz, EP '52
PICTURE BRIEF—ENGINEERS IN ROTC 26
by Robert M. Stuckelman, EE '54
BOOK REVIEWS 30
ENGINEERS' DAY—1952 32
TECHNIBRIEFS 40
FARCE! 52
LETTERS TO THE EDITOR 58
CIVIL ENGINEERING, CLASS OF 1952 66
ELECTRICAL ENGINEERING, CLASS OF 1952 66
STRESS AND STRAIN 68

COVER—Midshipmen Richard Crews and Walt Bortko perform an inclining experiment on a model to check the stability curves on the blackboard.
—*Stuckelman*

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Metal Transfer in Arc Welding

By PAUL J. WISNIEWSKI, MetE '53
and DAVID A. THOMAS, MetE '53

The electric arc was first employed for the welding of metals by de Meritens in 1881. Using a carbon electrode he successfully united parts of storage battery plates, the heat being obtained from an arc between the carbon electrode and the lead of the battery plates. Shortly thereafter Slavienoff modified this process by replacing the carbon electrode with one of metal. He noticed that the metallic electrode was consumed by the arc and supplied metal to the work being welded. This is the first recorded instance of metallic arc welding, which was patented in 1889.

This original work in the field of arc welding was done with what is now termed "straight polarity." Using a direct current source of power the metallic electrode was connected to the negative pole of the power source and the work to the positive pole. This particular arrangement is used today in conjunction with certain types of electrodes. One other arrangement employed reversed the above situation and had the electrode as the positive pole and the work negative. This process is now termed "reverse polarity" welding. The third practical metallic arc welding circuit employs alternating current.

Various types of electrodes have been devised for these different circuit arrangements, and, in general, they may be divided into three categories: bare electrodes, those coated by materials which form heavy slag deposits on the work, and those coated by materials which form protective gaseous atmospheres around the arc. Each of the two types of coating performs both of the functions, forming slag and maintaining a protective atmosphere, to some extent. The clasification above is made on the basis of the primary kind of protection provided.

The arc welding was improved considerably by the invention of coated electrodes. Both types of coating tend to protect the molten weld metal from the atmosphere and thus improve weld soundness. The slag-forming coating is said to accomplish this by forming a thin coating of the slag on each particle of electrode metal as it is transferred through the arc. This, however, has never been proved conclusively. The gas-forming coating is said to accomplish this protective action by creating an inert atmosphere around the arc. Both of these features are indicated schematically in Figure 1. There has been no attempt made in this drawing to show any metal being transferred from the electrode through the arc and to the metal being welded. This feature has not been included in view of the fact that the mode of this transfer is so much in question at the present time.

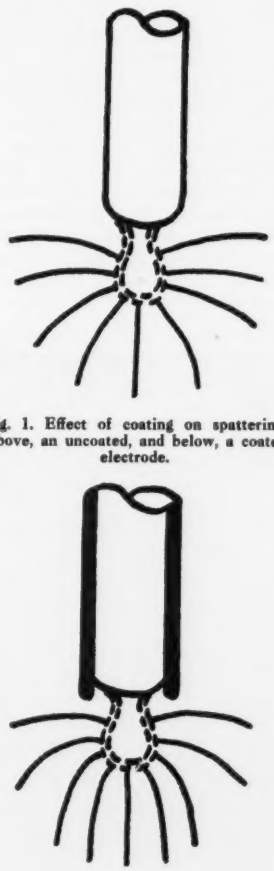


Fig. 1. Effect of coating on spattering. Above, an uncoated, and below, a coated electrode.

The term "metal transfer" as used in this article is defined as the transfer of small particles of the electrode metal through the electric arc to the work metal. The mechanism or mechanisms involved in this metal transfer have been matters of great interest ever since the inception of the metallic arc welding process. In view of the fact that the properties of the weld are determined in great part by the metal deposited from the electrode, the mode of this transfer is of great importance. If the nature of this mode of transfer were known and completely understood, electrodes, electrode coatings and welding methods could be designed with this factor in mind, resulting in more efficient operation and possibly a new welding technique not now known.

Theories of Metal Transfer

The interest shown in the metal transfer concept is indicated by the numerous theories which have been advanced to explain the phenomenon. These speculations go back to the time of the discovery of the process and each of the following theories has been proposed:

1. Vaporization of electrode metal in the heat of the arc and subsequent condensation on the work metal.
2. Transfer by means of gravity effects.
3. Transfer by means of the electrical pinch effect.
4. Transfer by means of electrostatic forces.

5. Transfer by means of electric effects.
6. Transfer by means of surface tension.
7. Transfer by means of the gas stream from the weld rod coating.
8. Transfer due to the pressure of the cathode spot.
9. Transfer by means of the expansion of gases in the electrode metal at the electrode tip.

Before a discussion of the various theories is undertaken, it would be desirable to set forth the characteristics which an ideal theory should possess.

1. The ideal theory should explain the transfer of metal with all possible combinations of current, electrodes, and positions of welding in which transfer is observed to occur.

2. The theory should explain why transfer does not occur in any case where such a situation is observed. Related to this is the fact that even though certain combinations of electrodes and welding conditions are not employed commercially, metal is actually transferred. For example, overhead welding is not practical with certain heavily coated electrodes because the deposited slag and metal tend to fall away from the work. Similarly, other coated electrodes are not used on alternating current or on direct current with straight polarity because of excessive spatter. However, in both of these cases metal is actually transferred. Such cases should also be covered by the ideal theory.

3. The theory should be in no way condradictory to observed facts.

Discussion of Theories

The various theories listed above will be discussed in the light of observations of metallic arc welding and experimental data if this is available.

Vaporization and Condensation

As implied, this theory is based on the assumption that the electrode metal is vaporized in the intense heat of the arc and then condensed upon the relatively cooler work. The theory is consistent with observed facts in that it adequately explains that transfer of metal in all welding positions with all electrodes and welding currents. However, the theory cannot account for the presence of macroscopic globules of metal in the arc and in the spatter. Evidence of these globules can be seen in various photographs of the metallic arc[3]. Furthermore, calculations have been carried out which show that the energy available in the arc is only sufficient to vaporize a small percentage of the metal actually transferred[2].

Gravity

This theory does not postulate that gravity alone is the explanation for metal transfer, but does imply that gravity has an effect. It must be concluded, however, that gravity effects are of negligible importance since the rate of metal transfer, as measured by the electrode melting rate, is essentially the same in overhead welding as in the down-hand position.

Pinch Effect

When a high current passes through a liquid conductor the liquid experiences a radial compressive force which tends to pinch the conductor until the circuit is broken. This theory is carried over into the metallic arc as follows: a molten globule is assumed to grow on the electrode tip until it short circuits the arc. This globule is then detached from the electrode by the pinch effect. This theory is discredited by the use of coated electrodes in which very short circuits occur in comparison to bare electrodes, which in turn show a high enough frequency of short circuits for the theory to be plausible.

Electrostatic Forces

Electrostatic forces tend to move particles from the positive to the negative pole of an electric arc. Thus this theory explains metal transfer in reverse polarity welding, but falls down when either alternating current or direct current on straight polarity is used.

Electric Effects

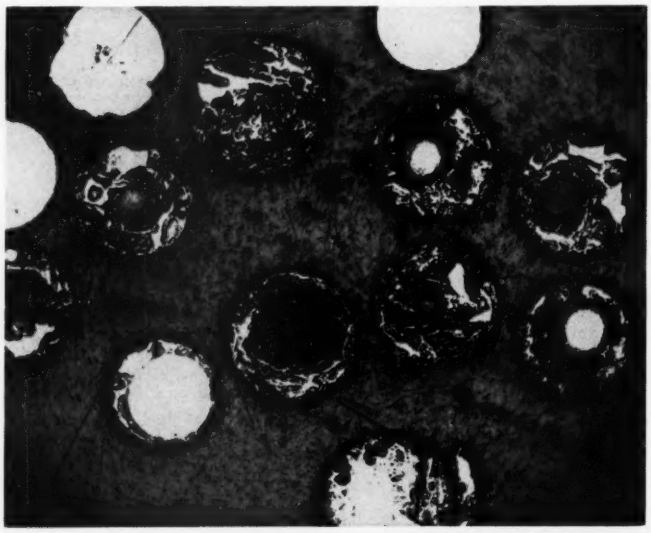
Electric effects have been described as the forces which tend to move particles through the arc from the negative to the positive pole. This theory explains polarity welding but not reverse polarity or alternating current welding.

Concerning the electrostatic and electric effects it seems hardly possible that one theory should apply for straight polarity, another for reverse polarity, and neither for alternating current welding. There is nothing to be gained by postulating separate theories for different sets of conditions.

Surface Tension

It is impossible to conceive of surface effects drawing metal across the arc space, which is, in some cases, as great a distance as one quarter of an inch. Furthermore, the surface tension theory

Fig. 3. Photomicrograph of electrode metal collected by the authors. Magnification 100×.



cannot readily explain the great distances to which metal is spattered under some conditions.

Gas Stream From Weld Rod Coating

Undoubtedly the velocity of the gas stream, which is produced by certain electrode coatings, does tend to impart a velocity in the same direction to the smaller particles in the arc space. The extent to which this occurs cannot be determined experimentally or evaluated theoretically. However, it does not seem probable that this gas stream could seriously affect some of the larger particles which are known to be in the arc. In addition, welding is done with bare electrodes in the absence of such a gas stream.

Pressures of the Cathode Spot

This theory was proposed to explain the transfer of metal in overhead welding on straight polarity. It states that the pressure of the cathode spot on the molten electrode tip depresses the liquid at this point. The arc then shifts to the new high point on the electrode and in this manner the molten globule of electrode metal is caused to undulate until it short circuits the arc. Surface tension then draws the electrode metal into the molten pool on the work metal. This theory, of course, applies only to straight polarity welding and as such is not in harmony with the

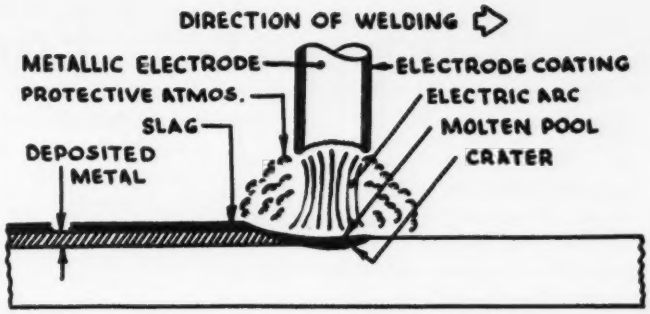


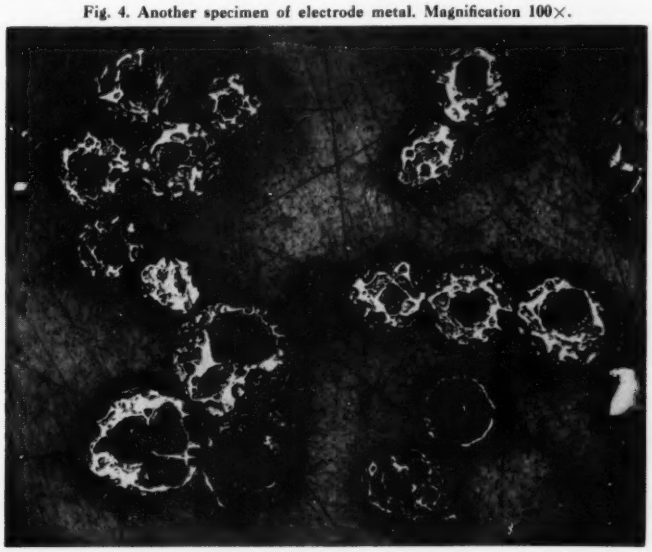
Fig. 2. Schematic representation of the shielded metallic arc.

characteristics of the ideal theory mentioned previously. This is not the only argument against the theory, however. Several investigators in their studies of very poor electrodes which had been treated so as to be gas free, found that overhead welding with these electrodes on straight polarity was impossible. The cathode spot theory has no explanation for this fact.

Expansion of Gases in the Electrode Metal

It is a well known fact that commercial steels contain dissolved gases and volatile inclusions and elements such as manganese which are vaporized in the heat of the arc. Since the solubility of gases in metals decreases with temperature, it is logical that the heat of the arc would cause the evolution and subsequent expansion of these gases at the electrode tip. These gases probably form below the metal surface, and in conjunction with surface tension effects cause the formation of metallic bubbles. Depending upon the thickness of the molten metal wall, these bubbles could either continue to grow, as the gases expanded, until they short circuited the arc and literally exploded, or else they could burst due to internal gas pressure alone. If the liberation of these gases is rapid, small bubbles may actually be shot off the electrode tip. Furthermore, the localized liberation of these gases could cause the simultaneous formation of several bubbles on the electrode tip. The bursting of one of these bubbles would then quite probably dislodge others, still intact. Thus it would seem that the metal transferred across the arc and the spatter metal would be partially in the form of hollow particles and partially in the form of solid particles

Fig. 4. Another specimen of electrode metal. Magnification 100×.



Experimental Evidence

Evidence to this effect is presented in Figures 3 and 4 which show cross sections of both types of particles. These photomicrographs were taken of electrode metal collected in the following manner: A weld was made along the edge of a plate in such a manner that most of the spattered metal and some of the metal transferred through the arc could be collected in a large tray of water approximately three inches below the arc. The particles were mounted in lucite and cross-sectioned for examination by grinding and polishing. Not all of the particles are sectioned at their equators and

(Continued on page 50)

Loudspeaker Enclosures

By PETER H. PINCOFFS, EE '52

The advent of long-playing records has not only caused major changes in the field of recorded music and speech but has placed increasing emphasis on the need for high fidelity sound reproduction equipment. A fact not commonly recognized is that the loudspeaker and its associated baffle may be almost totally to blame for the poor performance of the typical commercial radio-phonograph. This poor performance has stimulated a tremendous growth of an industry devoted to producing the components of faithful sound reproduction. In line with this increasing interest in better sound reproduction, the following is an attempt to compare three typical high-quality loudspeaker enclosures: the totally enclosed, the bass reflexed, and the horn-loaded. The discussion is thus limited because these three types are the only well-known ones that do not have characteristics either making them unsuitable for use in high-quality home-reproducing systems or limiting their application to very special situations.

The three enclosures are considered from two points of view: first, performance; and second, nontechnical attributes such as cost, size, and difficulty of home construction.

Considerable difficulty is encountered in setting up a just basis for comparison of enclosure systems as widely different as those under discussion here. Therefore, an attempt it made to "handicap" the various systems in the same way that a prospective purchaser or constructor would discriminate against them, even though this approach is by no means just from all points of view. It is assumed that the enclosures compared are of optimal design and construction, and are adjusted according to the most scientific current practice, and that their performance is measured in anechoic surroundings. Further restrictions assumed are that the loudspeakers used in the totally enclosed and bass-reflex systems are identical and that the loudspeaker used in the horn-loaded case is such that the resultant acoustic output power is the same as that of the other two at a frequency in the mid-range of the system. It is also assumed that the overall volume enclosed by each of the three cabinets is the same.

Performance is best compared by an evaluation of four different characteristics of speaker systems as a whole: frequency response, distortion, transient response, and efficiency.

Frequency Response

Before evaluating the contributions of the enclosures to frequency response, it would be well to consider the significance of the various ranges of frequency response. Although it has been known for many years that good overall frequency response is necessary for "balance" in sound reproduction, it has only been fairly recently that the full importance of the low-frequency performance has been recognized. It has been shown that the proper reproduction of even 500-cps staccato flute passages requires that the pass band of the system extend as low as the frequency of interruption of the bursts of tone. Research has proven the need for smooth speaker-system response below the lowest desired frequency by a consideration of the effect of this response on amplifier distortion. Since the low-frequency response characteristic of a loudspeaker system is primarily a function of the speaker enclosure, it is an important basis of judgement of such enclosures.

A related quantity of some importance in transient reproduction is the rate of low-frequency cut-off, a moderate rate of cut-off being most desirable. The high frequency response of the speaker system is considered only from the point of view of whether or not a coaxial or dual-cone type speaker may be employed. This aspect of the given enclosure is of importance because phase shift between low-frequency and high-frequency speaker units often causes poor transient response unless the units are coaxially mounted.

A comparison of the three types of enclosures on the basis of frequency response shows each to have some distinct advantages and disadvantages. The totally enclosed type has the advantage of the most gentle rate of cut-off. Furthermore, the frequency at which its response is 10 db below mid-band value is approximately the same as that of the bass-reflex type. The bass-reflex enclosure, however, shows something of a bass-boosting effect at low frequencies and, at frequencies approximately 50 per cent above cut-off (arbitrarily defined here as the frequency at which response is 10 db below midband), it produces over 6 db more output than the completely enclosed baffle. The

horn-loaded system is somewhat at a disadvantage compared to the other two in frequency response, because of the limitation in size. However, if it is assumed that the other two systems employ 15-inch speakers (as would be necessary for high-quality performance) and that the type of horn-loading system is one in which the horn is folded so as to obtain a large horn in the minimum space—the Klipsch System being a typical example—then the horn-loaded system has a frequency characteristic quite similar in shape to that of the totally enclosed baffle. Indeed, it is claimed that the effective cut-off frequency may be made slightly lower. Comparison with regard to high-frequency response again shows the horn to be at some disadvantage, because the highest frequency it can pass is only of the order of 500 cycles, whereas the other two systems both allow the use of wide-range coaxial or duo-cone speakers. The limited frequency response of the horn enclosure is, of course, caused by the unavoidable absorption of high frequencies in the tortuous path of its folded construction.

Speaker Distortion

Distortion, the second basis for comparison of the three speaker enclosures, is of two types: first, distortion originating in the loudspeaker as a result of non-linear operation, and second, distortion originating in the amplifier, but caused by the impedance characteristic of the loudspeaker.

Non-linear distortion originates in the loudspeaker, primarily because the cone makes too large excursions, causing its suspension to exhibit a changing degree of compliance and carrying the voice coil into regions where the magnetic field is no longer constant. One method of reducing this sort of distortion is to increase both the size of the speaker suspension and the axial length of the magnetic field. This remedy is decidedly expensive, however, as the amount of magnetic material needed to produce appreciable improvement is large. Another and more direct method is to arrange the enclosure so that the speaker can deliver the same acoustic power without causing as large excursions of the cone. It is seen, therefore, that the degree to which the enclosure acoustically loads the speaker and thereby reduces its cone excursion is another basis for comparing enclosures.

Distortion caused by the effect of the speaker impedance characteristic on the amplifier occurs mainly in the neighborhood of a peak in impedance, such as that at the fundamental resonance of the speaker. The distortion is produced because, at frequencies near resonance, both the scalar value and the angle of the impedance change very rapidly, causing the operating path of the amplifier output tubes to tend to be circular instead of narrowly elliptical and driving the tubes near, or beyond, cut-off. There are at least three methods of reducing this sort of distortion. A common remedy is to electrically damp the speaker by applying heavy inverse voltage feedback from the output terminals of the amplifier. Another less common and much more inefficient method involves the use of the equivalent of a shorted turn in the speaker voice-coil. A third procedure utilizes a speaker enclosure formed to "smooth out" speaker impedance variations by increasing the acoustic loading on the speaker, at least at the frequencies near fundamental resonance, and sometimes over a broad frequency band.

Compared from the viewpoint of effectiveness in reducing distortion, the completely enclosed system is the most unsatisfactory of the three under discussion. Engineering research has shown that the distortion of a particular totally enclosed system using a 15-inch speaker is as much as four times that of a bass-reflex system of the same overall size utilizing the same speaker. This difference in observed performance between the two systems is

Fig. 1. Sectional side view of the Klipsch folded-horn type loudspeaker enclosure, providing for a large horn in the minimum space.

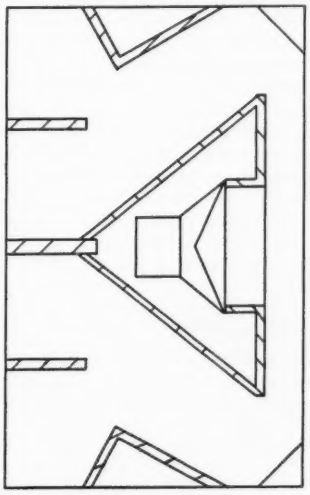


Fig. 2. Top view of the Klipsch enclosure as used for corner-mounting.

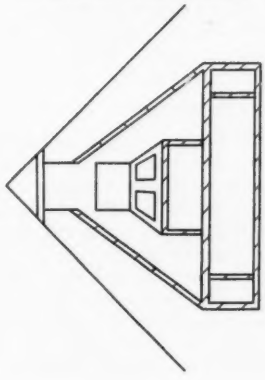
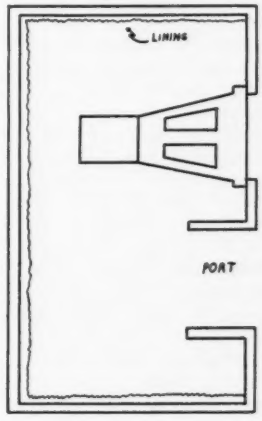


Fig. 3. Sectional side view of the reflexed cabinet type enclosure showing speaker and port.



primarily caused by the increase in acoustic loading on the speaker in the bass-reflex cabinet at resonance and also by the reduction in the large variation in impedance in the same frequency region. It is possible to obtain further improvement in the bass-reflex cabinet by making the impedance curve practically flat by utilization of resistive material in the port and immediately behind the speaker. The horn superior to both of the other enclosures from the standpoint of reducing speaker distortion. Not only is the acoustic loading by the horn greater than that of the bass-reflex cabinet (except in the region of the speaker fundamental resonance), but also the horn continues to load the speaker very effectively at frequencies far above the fundamental resonance. Therefore, cone movement, and hence distortion, is considerable lower in the case of the horn than in that of either of the other two enclosures.

Transient Response

Transient response, the third basis for comparing performance of the encloures, is primarily a function of damping, both of the fundamental resonance and of resonance in higher modes. The use of electrical means and of proper design of the enclosure as means of providing adequate damping of fundamental resonance has been well known for some years. Since good transient response is of primary importance in musical reproduction, the degree to which the enclosure produces good damping is of great importance. It is admitted, however, that in general, electrical damping by means of inverse voltage feedback in the amplifier can be used to compensate for any such shortcomings in the enclosure.

In attempting so solve the problem of damping in higher modes, however, it has been found that electrical damping is wholly ineffectual. The reasons for this fact lie in the nature of this sort of resonance. The existance of a very large number of resonant modes in the cone of a typical direct radiator loudspeaker has been proven. Additional research shows that many of these modes posses a high Q and are practically independent of the voice coil. Attempts to control these higher resonances by electrical means are therefore fruitless. The only effective means of such control it has already been of such control is by increasing acoustic loading on the speaker diaphram.

Since it has already been noted that the horn-type enclosure produces, on the whole, both heavier and more widely distributed acoustic loading on the loudspeaker—that either of the other two enclosures, it would be expected that the horn would show superior damping of resonances in higher-order modes. This is now known to be true. Even a short acoustic horn is capable of practically eliminating higher order resonances, which both electrical damping and absorbent material damping are not capable of doing. Both theoretical and experimental work indicates that the bass-reflex cabinet is only slightly superior to the totally enclosed cabinet in providing acoustic loading at any frequencies higher than about twice that of fundamental resonance. The horn, therefore, is definitely superior for high-frequency damping.

It has already been observed that the bass-reflex cabinet has valuable acoustic loading properties at and near the frequency of fundamental resonance, whereas the totally enclosed cabinet shows practically no loading effect. As would be expected, therefore, the bass-reflex enclosure shows superior damping of the fundamental speaker resonance and in general gives transient response superior to that of the totally enclosed system. However, with respect to transient response as a whole, the horn-loaded enclosure is definitely superior to both of the other two systems.

Speaker Efficiency

The efficiency of a loudspeaker system, the final basis for comparing the enclosures, is mainly determined by the acoustic loading on the loudspeaker. Since the horn-type enclosure produces by far the highest average acoustic loading of the three enclosure systems considered, its overall efficiency is also considerably above that of the other systems. This discrepancy in performance is most pronounced at frequencies several times the low cut-off frequency, where the efficiency of the horn may be on the order of three to four times that of the other two systems. However, even at the extremely low frequencies in the region of cut-off, the efficiency of the horn remains slightly higher than the bass-reflex and markedly higher than the totally enclosed type. As has been inferred, the bass-reflex system shows efficiencies comparable to the totally enclosed system at frequencies well above resonance, but in the extreme low frequencies in the neighborhood of resonance and cut-off, its efficiency is distinctly superior. It follows, therefore, that a speaker of lower power rating than that used in the other two enclosures and requiring less magnet material, is necessary to obtain the same power output from the horn-loaded system.

Since not many connoisseurs of high-quality sound reproduction have unlimited funds with which to indulge their technical whims, cost is a consideration of some importance in comparing these three enclosures. Unfortunately for the audio hobbyist with a thirst for perfection, desirability and high cost seem to go hand in hand. The very complexity of the Klipsch-type folded horn, which allows the achievement of its desirable performance while maintaining its small size, also results in its high cost. However, it is some consolation that, although the enclosure for the Klipsch system is much more expensive, the low frequency speaker may be somewhat less costly in that it requires a lower power rating than that required by the other two speaker systems. Resort to simpler folded-horn structures, which are of consequent lower cost, usually result in greatly increased size for the same performance, with decrease in desirability.

Relative Costs

There is no very substantial difference in cost between totally enclosed and bass-reflex cabinets of the same overall size; however, both are considerably cheaper than

(Continued on page 40)

Electroplating - Science and Industry

By EDWARD LEVENTHAL, EP '56

The significant feature of electroplating as an applied science is the fact that its intricate procedures are still in the process of being scientifically explained and classified. For years, men in the electroplating industry were achieving results by trial and error methods, and it is the results of these methods which dominate the field today. A serious and energetic attempt to analyze and explain these methods was undertaken by the Electrochemical Society in 1911. Twenty-six authorities went to work and published their results in 1941. The attempt was extremely successful but nevertheless incomplete. This modern process of development from industry to science is a unique situation and worthy of further discussion.

The modern theory of the phenomenon involved in electroplating is briefly this: chemical solutions dissociate into particles called ions, which possess electrical charges. If an electric current is passed through a conductor into a solution and out through another conductor, the negative ions will migrate to the more positive conductor, called the anode, and the positive ions will migrate to the more negative conductor, or cathode. If the solution is one which contains metal ions, the positive metal ions will be neutralized and deposited on the cathode. By employing an article to be plated as the cathode, and a solution of a chemical substance which contains the metal with which we wish to plate the article as the electrolyte, we may obtain the desired plating.

Variety of Applications

With little more than this as a foundation the electroplating industry developed. Since its initial appearance practically all the commercially available metals have been successfuly plated on articles of varying composition, including non - conductors. Non - conductors are prepared for plating by spraying them with finely divided silver, or by treating them with a solution or series of solutions which will deposit a metal precipitate on the surface. Both methods convert the non-conductor into a conductor and have made possible the plating of such materials as leather and pottery.

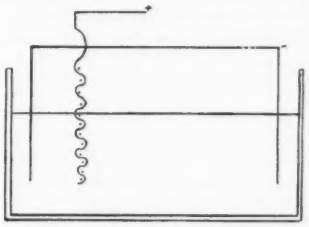


Diagram of a throwing-power cell.

The industry soon recognized that the factors which influenced the quality of the finished product were many, and that they varied considerably with the individual metals. Terms such as throwing power, current density, and pickling, were originated and the results of practical experience in the shop were collected, classified, and consistently improved upon.

Throwing power is used to describe the ability of an electrolytic solution to plate uniformly. Thus an electrolyte with good throwing power will require fewer electrodes to provide complete coverage of the article than one of less throwing power. Copper solutions used in plating have exceptionally good throwing power, and are responsible, in part, for the popularity of copper plating. In one type of cell designed to measure throwing power, two cathode plates having exposed areas of 25 square centimeters are placed in the solution under observation, 2.5 and 12.5 centimeters from a gauze anode. The throwing power of the solution is determined by the ratio of the weights of deposits on the two cathodes.

Current density is the amount of electric current per unit area of electrode, usually measured in amperes/sq. cm., amperes/sq. dec., or amperes/sq. ft. It is specified for the cathode and anode individually in each electrolytic solution. The proper current density will vary with the temperature of the solution, with a higher temperature generally requiring a greater current density. The common range of current density is from .5 to 20 amperes/sq. decimeter, but this again is subject to various conditions, including the polish desired on the coating, the smoothness of finish which is required, and the speed of the process.

Preparation of Article

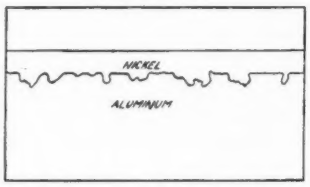
The chief use of electroplating is for external protection. Decorative and ornamental purposes follow next in order, although the use of electroplating to increase the size of worn down precision parts is becoming increasingly important. Probably the most critical aspect of the entire process is the condition of the article when it is immersed in the plating tank. It must be absolutely smooth and clean or the plating will be to no avail. The article is first buffed smooth on a series of rotted stone, sand coated and cloth wheels, in that order. This is an extremely delicate process, and requires skilled control of pressure, position, and time. The article is then pickled. Pickling is a preparatory process which involves dipping an impure object in acid solutions which attack oxides and welding scales on the surface, and which, in some cases, increases the luster of the article. Baths of potash or caustic soda are also used for pickling, and in many cases an electric current is passed through the pickling solution in order to speed up the process and to prevent some solutions from attacking the metal itself. If the item has an oily coating on it, it is immersed in a benzene or carbon tetrachloride solution. In all cases the object is washed in water and carefully checked before it is accepted for the electro-deposition steps.

If a zinc, cadmium, or tin plating is to be applied, the item is plated directly. Agitation of the solution prevents any gas formation from cutting off the process, and strategically placed electrodes will insure complete coverage. Zinc plating is used mainly for the protection of iron and steel from corrosion by water in the cases of underseas and outdoor equipment. The best protective plating is provided by a zinc cyanide solution, with a current density of about 2 amps/sq. dec. and a temperature of about 40 degrees Centigrade. The introduction of mercury or molybdenum to the process, either in solution or by means of the anodes, will increase the brightness of the finish.

Cadmium, plated alone or in combination with zinc, has found its greatest use in the protection of industrial and underseas equipment. Recent tests have shown that a zinc-cadmium coating lasts longer than one of either metal alone. Tin may be plated from an acid or alkaline bath, although the acid bath gives better current efficiency. A solution of tin sulfate, sulfuric acid, and glue, at a current density of 1 to 2 amps/sq. dec. and a temperature of 40 degrees Centigrade would be generally satisfactory.

Base Metals

If the article is to be plated with chrome, nickel, silver, or gold, it requires a base metal, usually copper, before the final plating. This base is necessary for nickel and chrome, and very desirable for silver and gold, because it increases the durability and color of the finished product. The base is applied for about one minute at a very high current, and then for about two hours at a smaller amperage. The initial "strike" will prevent acid in solution from affecting the object during the process. The article is next cleaned in a cyanide solution to neutralize any acid which adheres to the surface, and then rinsed in water to neutralize the cyanide. The object is then checked for uneven deposits on the surface called blisters. If there are several noticeable blisters, all the copper must be removed and the entire process begun over again.



Nickel-plated Aluminum. Magnification 500×. (Diagrammatic.)

Chromium plating is perhaps the most important of the recent developments in the electroplating field from the commercial angle. The bright polish, durability, and resistance to stains which result from a proper chromium plating have made it desirable for items designed to appeal to the public taste for beauty and value. However, chromium solutions have poor throwing power and the process is a difficult and exceedingly precise one. A slight variation from the proper conditions of concentration, current density, temperature, or time of reaction will seriously affect the results. To generalize on these conditions would be misleading and consistent with the extreme delicacy of such an operation.

Nickel is used as a base metal for chrome finishing, as a component of nickel-cobalt coatings, which are very durable and lustrous, and as a protective element in its own right. Gold and silver, the more expensive, and consequently less practical, metals to plate, from an industrial standpoint, have found extensive use in the finishing of jewelry, ornaments, and similar finery. Their popularity is established, however, and a good deal of time is being devoted to the improvement of polish and color of these platings. Gold, for example, has been plated with varying shades of green, red, and white by adding silver cyanide, copper, and nickel respectively to the electrolyte.

An interesting sidelight to the plating industry has been the discovery of the fact that certain metals, when plated in increasing thicknesses, produce colors which repeat themselves in cycles. Copper oxide, if plated in thin uniform coats, will produce a new color at regular time intervals until nine cycles of five colors each have elapsed.

Progress to be Made

The industry at present is handicapped by a lack of standardization, which in many cases leads to outright guesswork on the part of employees. The very nature of the work involves details and specific relationships too numerous to record, and many successful combinations and specialties, like a cook's recipes, remain unpublicized, unclassified, and unexplained. The growth and expansion of the industry, however, coupled with the newly aroused theoretical interest in electroplating, are significant omens of the way ahead; and as problems pass from the shop to the laboratory, as science and industry progress hand in hand, we may look confidently to the future and predict increasing benefits from the field of electroplating.

Industrial Air Pollution

By IAN J. MARWICK, EE '53

In recent years the problem of air pollution has become increasingly important. Pollution presents not only a problem of appearance, but also a problem of health and economics. A city with smog-laden atmosphere is not only an unpleasant, dirty, place to live, but is also unhealthy when certain toxic compounds are contained in the smog. Municipal authorities have paid special attention to air pollution in recent years, and many cities have special smoke ordinances regulating the amount of air pollution from industrial smoke stacks. Industry is interesting in preventing air pollution because many materials contained in the smoke and gases can often be recovered and reused or sold.

The measurement of smoke intensity in a chimney is complicated by the very nature of smoke itself. The smoke tends to cling to, and coat, lenses and glass placed in the chimney, necessitating high maintenance costs and affecting the accuracy of the instruments. If samples of smoke are drawn off, the smoke clogs the pipes with fly-ash and cinders. This clogging necessitates high maintenance costs. The ambient temperature in and around the chimney affects electrical devices. Filament-operated devices have their accuracy affected by the varying temperature, and photoelectric cells change their emission qualities when subjected to long heat exposure. If the smoke is removed from the chimney to a cooler spot, rust and corrosion by water and sulfur condensates cause trouble with equipment. Because of the difficulties encountered in measuring smoke concentration, many methods have been devised, but none of them eliminates all of the difficulties just mentioned.

Qualitative Methods

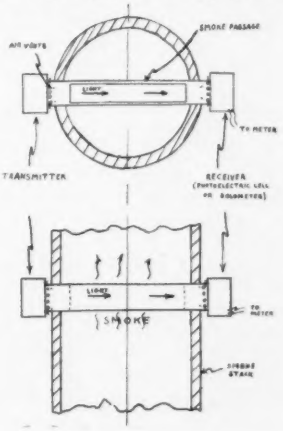
One of the earliest methods of determining smoke density was through the use of Ringlemann charts. At the time these charts were introduced, people assumed that the soot and fly-ash content of smoke was directly proportional to the visual density. Ringlemann charts consist of a series of black lines on a white background. The width of the lines and the area of the white spaces are varied to give different degree of intensity. These figures form a large chart which is placed in line with the chimney about fifty feet from the observer. A comparison of the apparent grayness of the charts with the visual density of the smoke gives a Ringlemann number between 0 and 4 as a measure of the smoke density. Ringlemann charts provide an easy, fast, and cheap method of determining smoke density. They determine only the apparent visual density, but since this is what the public sees and is concerned about, many cities specify a maximum Ringlemann number in their smoke ordinances. The disadvantages of Ringlemann charts are as follows:

1. The type of illumination through the smoke has considerable effect on the readings. If the sky is light a higher reading is obtained than if the sky is dark because the charts measure the amount of light transmitted through the smoke.
2. Wind velocity affects the readings by dispersing the particles more rapidly.
3. High humidity will give a higher reading because the smoke tends to remain concentrated and is not so easily dispersed by the wind.
4. The diameter of the chimney affects the reading because the smoke has more opportunity to disperse inside the chimney, although the actual amount of smoke may still be the same.
5. Difficulty is found in obtaining consistent readings due to human error. The reading is a person's estimation of the color comparison, and will vary from person to person.

Ringlemann charts are acceptable for city control of smoke where apparent density is the chief factor, but will not give any quantitative readings of smoke measurement.

The umbrascope is a measuring device having a sighting tube into which smoked lenses may be inserted. These lenses are half smoked and half clear glass and as many as four lenses may be inserted in series in the field-of-view of the tube. By sighting the smoke through the clear glass and com-

Fig. 1. Schematic of eneregy transmission system used for measuring density of waste smoke products leaving the stack.



paring its intensity with the smoked lenses, a measure of smoke density may be obtained. The reading range from 0 to 4 corresponding to the number of lenses inserted to match the smoke density. This instrument is easier to use than the Ringlemann charts and is somewhat more accurate, but still has the same five disadvantages of the Ringlemann charts.

Quantitative Methods

The filter spot method of smoke measurement involves drawing a given volume of smoke through a filter paper and measuring the intensity of the dark spot produced. A sampling tube opening directly into the chimney removes smoke which is then drawn through the filter by a vacuum pump. The spot obtained is compared with standards ranging from 0 to 9 by steps of ½ a unit and a measure of the intensity is obtained. This method is reasonably accurate and has more gradations than the previous methods, but accuracy is affected by the color and size of the smoke particles. Light-colored smoke gives a low reading even though its particle size also affects readings. Large particles tend to give a higher reading than small fine particles, although the smoke intensities may be equal. Variations on the method are: Measuring the spot intensity by means of a photoelectric tube, which eliminates human error and achieves greater accuracy, but still does not compensate for light-colored smoke; Weighing the amount of smoke deposited on the filter paper, which will give a value independent of smoke color, particle size, and human error in comparing intensity.

Another method for measuring smoke intensity uses a cool glass rod which is inserted directly in the smoke chamber. The smoke, in passing over the rod, collects due to condensation and collision of particles with the rod. At one-half the exposure time, the rod is rotated 180 degrees to allow particles to collect evenly. At the end of the exposure time, the rod is removed from the chamber and readings of the smoke intensity are taken. Readings are made by inserting the rod into a special device, containing a photoelectric tube, which measures the amount of light transmission through the rod and gives a reading from 0 to 100 for low and high smoke intensities.

Energy Transmission Methods

Two systems of measurement involve energy transmission through the smoke. One measurement is made by a photoelectric tube and the other by a bolometer. The photoelectric method consists of a source of light which transmits radiant energy through the smoke to a photoelectric tube. The amount of light which the smoke transmits is measured by the tube and is recorded on a meter. The

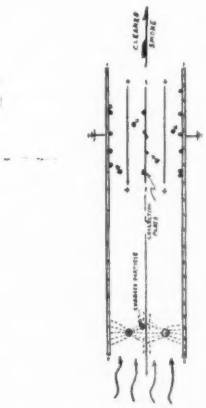


Fig. 2. The electrostatic precipitator uses high voltages to precipitate particles causing air pollution.

bolometer method is practically the same, except that it measures the amount of heat transmitted through the smoke. A parabolic reflector focuses the energy on a filament, thus increasing the filament temperature. As the temperature of the filament increases, its resistance is increased and recorded on a meter. The bolometer is briefly described in this section; the photoelectric measuring device is much the same except that the receiver is a photoelectric tube and not a filament.

The bolometer (Fig. 1) consists of a 4-inch diameter tube through a diameter of the chimney. A long slot 3 inches wide is cut through both sides of the tube and aligned with the direction of the flow of smoke. At one end of the tube is a light source, usually a standard 150-watt spotlamp. At the other end of the tube is the receiving element, a temperature-sensitive filament. The incident energy increases the temperature of the filament, thus increasing the filament resistance. This change in resistance is electrically translated into smoke intensity readings and recorded on a meter or graphic recorder. The energy reaching the receiving end of the tube is concentrated by a parabolic reflector behind the element, causing larger temperature changes and enabling the use of less-sensitive equipment. Often automatic equipment is attached to the bolometer output to control air or steam-jet valves in the heating system and thus automatically compensate for any increase in smoke intensity. The system can also sound an alarm if smoke concentration exceeds a maximum predetermined limit, signalling the operator to take corrective measures. The space in the receiver is evacuated to prevent oxidation and radiation inside. To counteract the problem of particles collecting on the lenses of the spotlight and bolometer, air vents are provided. Air enters these vents due to the sub-atmospheric pressure inside the smoke stack and continually removes any particles which could enter the ends of the tube and collect on the lenses. The indicator of the bolometer is usually a large bold-scale meter having a dial-length of about 30 inches. Another instrument often added is a graphic-recording meter to provide a continuous, permanent record of smoke intensity for reference by plant engineers, city officials, and other interested parties. The bolometer is calibrated at 100, the maximum smoke intensity, by extinguishing the spotlamp, giving a zero value of incident energy on the filament. To calibrate to zero, the instrument is operated when there is no smoke present in the smoke stack. The recorder now gives readings ranging from 0 to 100 which are directly proportional to the smoke intensity inside the smoke stack.

(Continued on page 36)

Faculty Profile

By DAVID SCHERAGA, ME '54

Professor Thomas J. Baird

The office at 101 East Sibley is somewhat bizarre. A pattern of criss-crossed strings forms an artificial ceiling half-way up the twenty-foot walls; a single bright yellow drape, extending from the ceiling to the floor, adorns the solitary window; freehand drawings line the walls; and to top it all off a conspicuous looking camshaft, suggestive of a lonely cactus plant, sits on the desk. These props are the result of Professor Thomas Baird's efforts to "humanize" his office and bespeak, in no small part, his enthusiasm for contemporary design.

It is not too surprising to learn, therefore, that Professor Baird is an architect by trade, although he has been instructing engineers in the rudiments of descriptive geometry and mechanical and freehand drawing since joining the Sibley faculty in 1945. These courses, by their inherent nature, have given him the opportunity to work *with* his students and know them as individuals rather than just as faces in a large lecture. They have been challenging, too, in that he has assumed the task of stimulating creativity and imagination in students whom, he feels, otherwise lack courses which develop these attributes. To him, these are the basic tenets of all professional work.

In freehand drawing, Professor Baird tries to accomplish the double purpose of immediate practical application of the material to engineering, plus cultural orientation to the expressions of the contemporary world. As he sees it, the same qualities are evinced in all modern expression, be it industrial design, architecture, music, painting or otherwise. To make his classes more appreciative of this, he takes them to various buildings and places on campus to witness examples of modern design, and to make them more aware of form and proportion. Aside from developing skill with the pencil, the course also molds the proper mental approach to the solution of design problems. Effort is made to establish and stimulate habits of creative thinking, utilizing the freehand technique to aid in the creation of ideas.

Professor Baird has become as much a part of the course as the material itself. His classes are warm and informal and students find that they can freely express themselves, both orally and artistically. He is soft-spoken, but emphatic and uses descriptive speech occasionally garnished with a mild epithet. The fact that he appreciates a good joke is made evident to anyone who converses informally with him.

The professor first came to Cornell in 1921 from Cleveland, Ohio, his home town. After receiving a bachelor's degree in architecture, he remained in Ithaca on a fellowship and eventually wound up designing exclusive homes throughout the country for the noted architect, Bryant Fleming. In 1940, another fellowship took him to the Cranbrook Academy of Art in Michigan, where he studied city planning and industrial design under the Finnish architect, Saarinen. He then returned to Cornell to teach landscape design in the floriculture department while working for the degree of Master of Regional Planning. The need for descriptive geometry instructors during the war then brought him to Engineering,

(Continued on page 42)

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Frederic C. Wood

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."

The importance of being able to use the English language to express our thoughts and to understand the thoughts of others is generally accepted today as a requisite for success in any field. It applies to doctors, lawyers, beggars and thieves. It also applies to engineers. An organization which has studied the correlation of aptitudes with attainments discovered that facility with language was a more common characteristic with bank presidents than facility with figures. Close scrutiny would probably reveal the same to be true of Hollywood producers.

That engineers as a group are deficient in being able to say what they mean or to understand what is being said to them is an old chestnut, to which I take exception. It has been harped on for so long that some of us are apt to get apologetic about it.

There may be a basis for such an assumption historically. Less than fifty years ago the standards for literary excellence (and for public speakers) included a floweriness which does not exist today. Engineering training has always been towards directness, simplicity and economy. It is understandable that an engineer's directness might have been interpretated as a deficiency in expression in the era of hoop skirts and frilly petticoats and corset stays—in the era of architectural gewjaws and gimcracks and fancy perches for pigeons.

In that age life was more simple, so we complicated the details. Now the world is complicated by our own inventions—there is too much going on—too great a demand on our time—so we are forced to simplify the details and take vitamin pills and read digests of digests.

Today, good writing and speaking calls for brevity and directness. It necessitates taking out useless words. The simple understandable word is preferred to the multisyllable word which requires a dictionary. It is the kind of expression for which an engineering training is well suited —a training in finding the shortest distance between two points, in using the minimum of labor and material. Perhaps there is a remote connection between this fact and the unprecedented demand for engineers.

Of course engineers are able to express themselves and do it well. The undergraduates who produce this magazine give us evidence of that.

Frederic C. Wood

ALUMNI NEWS

John W. Hurley, C.E. '10, came to Cornell from George Junior Republic at Freeville, where he had served first as judge and then as president, and of which he is now both a trustee and a distinguished alumnus. He brought with him a reputation for energy and integrity, together with a scholarship to Cornell supplied through the Republic.

After his graduation, John joined the U.S. Engineers and spent the next nine years combating the Mississippi River in the Memphis area through the construction of revetments and the Abattis dikes. After thirty years the Mississippi and the Hurley job are holding each other to a mutually creditable draw. In John's tenth year in the Memphis area, he built the Consumer's Cotton Seed Oil Mill as resident engineer for Swift and Company.

It wasn't until 1920 that John found his permanent niche in life, this time with the Griffin Wheel Company, manufacturers of railroad wheels in eleven plants scattered about the country. Beginning as resident engineer, he became in 1927 chief engineer of the Griffin Engineering Company, which under him has greatly improved foundry practice through the development of the Griffin Hot Blast Cupola, which uses waste gases to heat the incoming cupola blast and is now considered standard equipment in many firms.

John W. Hurley

The Hurleys live at 436 Arlington Street, Glen Ellyn, Illinois. They have a son and two daughters, all married, and four grand-children to date.

Among the 50 Americans chosen in the January issue of Popular Mechanics for a "Golden Anniversary Hall of Fame," were a Cornell faculty member and two alumni. The group was selected on the basis of success in mechanics, science, and discovery. Professor Hans A. Bethe of the physics staff was recognized for his "basic research in theoretical physics, his theory of atomic nuclei, his discoveries on the energy production of stars, and for his shock wave theory." Thomas Midgely, Jr., '11, was honored "for his discovery of the antiknock properties of tetraethyl lead. . . . vital to powerful and modern engines." Professor I. I. Rabi, '33, of Columbia also received notice "for discoveries in physics pertaining to magnetism in regard to molecules, resulting in much new information in the atomic and molecular structures; also for radar research."

Eight Cornell engineers working in various parts of North Africa, met on January 17 at the Key Club in Casablanca, Morocco. They are **Salvatore J. Scacciaferro, '21, William F. Summers '14, Michael Martirosian '30, Walter A. Rutes '49, David J. Swift '50, Louis J. Amadio '50** and **Alexander D. MacDonald '51.** The group hopes to meet monthly.

James J. Munns, C.E. '14, has had an address published in brochure form: "Differential Coated Electrolytic Tin Plate." He is vice-president of the Weirton Steel Company, Weirton, West Virginia.

Frederick Ohrt, C.E. '11, has been elected an honorary member of the American Society of Civil Engineers. The recognition was for his work during the last quarter century in water development and conservation and his studies of salt water intrusion on Pacific islands, with special emphasis on the water resources of Hawaii. Ohrt is manager and chief engineer of the Honolulu water system. He lives at 2958 Nuuanu Street, Honolulu, Hawaii.

Frederick Ohrt

Sephen C. Hale, M.E. '12, is the chief engineer at the Fulton Bag and Cotton Mills in Atlanta, Georgia. He lives at 1403 Emory Road NE, in Atlanta.

Howard P. Corwith, M.E. '16, is vice-president in charge of development and research with Western Union Telegraph Company, 60 Hudson Street, New York City 13.

Alfred R. Thomas, M.E. '23, vice-president of the Guaranty Trust Company of New York, has been advanced "to become associated with general management" of his company. He has been vice-presi-

(Continued on page 48)

NEWS OF THE COLLEGE

McIlroy Appointed Assistant Dean

Cornell's President, Deane W. Malott, has announced the appointment of Professor Malcolm S. McIlroy as assistant dean of the College of Engineering at Cornell, effective July 1. Professor McIlroy will give some time to dean's office affairs this spring to be in position to carry on following the retirement of Assistant Deans Walter L. Conwell and Robert F. Chamberlain this summer. He will continue in his present capacity as assistant director of the School of Electrical Engineering until July 1.

Professor McIlroy was graduated from the electrical engineering course at Cornell in 1923 and received the Doctor of Science degree at Massachusetts Institute of Technology in 1947. Before joining the Cornell staff in 1947, he was with the General Electric Corp., Poughkeepsie. He also taught at M.I.T., and during the war was assistant director of the M.I.T. Radar School.

Professor McIlroy

Dr. George Winter, head of the Department of Structural Engineering in the School of Civil Engineering at Cornell, has been appointed to an advisory panel on structural engineering of the National Research Council's Building Research Advisory Board.

The seventeen-member group, on which Professor Winter is one of two college representatives, will advise primarily on matters of conservation in building construction.

Lounge Remodeled

Students and faculty members will soon be treated to a brighter and more comfortable place to relax as a result of the remodeling now being done on the Engineer's Lounge in Sibley basement.

Recognizing the need for new furniture and fixtures, Kappa Tau Chi honorary recently staged a fund-raising campaign to finance the project. Its goal was to solicit enough money to purchase new lights, magazine subscriptions, games, furniture, ashtrays and other items to dress up the otherwise plain looking room.

The Department of Buildings and Grounds has consented to recast the entire floor, which was in dire need of repairs, and lay a new one covered with tile. It will also build a cinder-block wall to conceal the steam controls and pipes.

A committee is now being formed to supervise the lounge and promote it as the focal point of all engineering activities. Any student interested in working on the committee is requested to contact Jim Beveridge at It. 4-9146.

NACA Appointments

Seven members of the staff of Cornell University have been appointed members of technical subcommittees of the National Advisory Committee for Aeronautics for 1952. The appointments are: Dr. Theodore P. Wright, Vice President for Research, reappointed Chairman of the Committee on Aerodynamics; Dr. C. C. Furnas, Director of the Cornell Aeronautical Laboratory, reappointed a member of the Committee on Aircraft Construction; Mr. W. R. Milliken, Jr., Manager, Flight Research, Cornell Aeronautical Laboratory, reappointed a member of the Subcommittee on Stability and Control; Dr. William R. Sears, Graduate School of Aeronautical Engineering, reappointed a member of the Subcommittee on Fluid Mechanics; and Mr. Clem Trimbach, Head Armament Group, Development Division, Cornell Aeronautical Laboratory reappointed a member of the Subcommittee On Aircraft Fire Prevention. New appointments are: Mr. Alexander H. Flax, Cornell Aeronautical Laboratory, appointed to the Committee on Aerodynamics; and Mr. William M. Duke, Pilotless Aircraft Manager, Cornell Aeronautical Laboratory, appointed to the Subcommittee on Aircraft Structures.

In making the announcement, Dr. J. C. Hunsaker, NACA Chairman, noted that the four hundred aeronautical leaders so honored would be of material assistance in formulating the NACA'S research programs to provide information required for the design of superior aircraft and missiles.

Appointees serve in a personal and professional capacity without compensation. Recognized for their leadership in a special field, they include engineers from the aircraft industry and the airlines, scientists from universities, and experts from the civil and military agencies of the Government most concerned with aeronautics.

Engineering Materials Fund

A fund-raising effort for an engineering materials center under construction at Cornell University is within $227,000 of its goal. Walter L. Cisler, president of the Detroit Edison Company and chairman of the thirty-nine member sponsoring committee, announced that $509,000 in contributions had been received since January, 1951. He stated that, with prior gifts included, the fund has reached $1,509,000 toward a final obpective

of $1,736,000.

Of the overall total, $285,000 has been given by corporations and foundations. Recent gifts include $75,000 from the Pew Memorial Foundation, Philadelphia, and $50,000 from the Olin Industries Charitable Trust, Inc., East Alton, Ill.

Construction of the materials center began early in 1951 and is expected to be completed before the end of this year. The structure will have two units: a materials processing laboratory named for Dexter S. Kimball, retired dean of the university's College of Engineering, and a materials laboratory, named for the late Robert Henry Thurston, who headed Sibley College of Mechanical Engineering at Cornell from 1885 to 1903.

Fifth-Year Projects

In order to acquaint fourth year students in Industrial and Administrative Engineering with their fifth year projects, Kappa Tau Chi, mechanical engineering honorary, sponsored an informal discussion at the Alpha Delta Phi fraternity house. It was led by three professors and six fifth-year students actively engaged in their projects. Professor Schultz explained the general purpose of the projects—to correlate much of the information gathered in the preceding four years. Professor Sampson commented more specifically on some of the recent projects, while Professor Saunders, advisor for the projects, added general comments and helped answer questions.

Construction of U.N Building

The United States Steel Corporation's film, "The Fabrication and Construction of the United Nations Building in New York City," was shown at the March meeting of the American Society of Civil Engineers. This technicolor production dramatically followed the week-by-week progress in erecting one of New York's engineering landmarks. On hand at the meeting was a representative of the American Bridge Company, who added some supplementary information on the film.

One of the principal projects of the A.S.C.E. has been the sponsorship of the Professional Engineering review classes. These classes, held periodically during the past several months, have been of considerable assistance to engineers preparing for their professional Engineer's Exam.

Professor Tani Joins Staff

Itiro Tani, professor of fluid mechanics at the University of Tokyo, has joined the Cornell staff as a visiting professor in the Graduate School of Aeronautical Engineering.

Dr. Tani, who is supported by a traveling fellowship from the Japanese government, will be at the university for at least six months. A specialist in the aerodynamics of wing sections, he will do research and lead seminar discussions on work in that field. In 1938 Dr. Tani and Dr. William R. Sears, director of the Graduate School of Aeronautical Engineering, found from technical journals that they were working independently on the same subject—the aerodynamics of aircraft landings; here at Cornell, they have become personally acquainted for the first time.

In 1939 Dr. Tani discovered the principle of the "laminar-flow airfoil," a type of wing section which has less resistance than conventional ones. The same idea was discovered independently in America at about the same time and has been applied to the design of certain high-speed aircraft.

Dr. Tani has worked more than twenty years in aerodynamic research and has incorporated the results in numerous papers and three books. His most recent volume, "The Science of Air Flow," has been adopted by the Japanese universities as a textbook for engineering students.

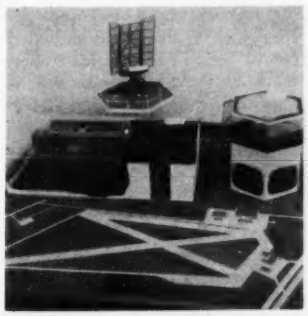
Airport Radar Model

A topic currently prominent in the public eye is air navigation and traffic control. Recent disasters at Elizabeth, New Jersey, have intensified this interest and have generated greater public demand for air safety than ever before.

In this field the electronics industry has not been caught napping. For many years it has been working for the improvement of air safety. One of its most recent contributions is an airport surveillance radar system (called the ASR-2) made by the General Electric Co. A detail model of this with a miniature airport was recently exhibited at Franklin Hall and may now be seen at the Cornell-General Electric Laboratory opposite Robinson Airport.

The ASR-2 is a medium range radar system which is specifically designed to give the air traffic controller an all-weather picture of traffic conditions within a thirty to fifty mile radius of the airport. In tests, it has been effective up to sixty miles from the station with no significant cone of silence over the antenna.

The receiving system of the ASR-2 has an efficient moving target identification component. This



A model of an airport equipped with the ASR-2 airport surveillance system.

eliminates responses from mixed targets, such as trees, hills, or tall buildings, while making stronger the responses from moving targets. An application of the Doppler effect (the change in frequency being due to the target motion) makes this possible.

The responses are indicated on a plan position indicator, which affords a continuous picture of the target's location in polar co-ordinates. A fluorescent screen makes the otherwise intermittent responses appear steady.

The operator of this search radar is enabled to direct aircraft through all sorts of complicated situations. Traffic, especially in bad weather, will be greatly speeded up. Twenty-eight ASR-2 units were manufactured at the time the General Electirc model was built, these to be installed in the United States and possessions, Belgium, and Holland.

Retiring Board of

The Cornell Engineer

Last year the ENGINEER had a team that was really "all-star." The season was a long one, but the players scored continuously and compiled a record that they can surely be proud of. Some of these "first-stringers" won't be in the line-up next year, but the work that they've done will be in the record book. To these men we extend our sincere thanks for the fine work they have done and our best wishes for the future.

RICH CHITTENDEN CE '52

One of the more prominent of this year's engineering graduates is Rich Chittenden. This past year, Rich has been editor-in-chief of the ENGINEER.

Born in Seattle, Washington (not far from the home of Dean Emeritus Kimball), Rich went to grade and high school in Edmonds, Washington, and graduated from Edmonds High School as valedictorian of his class. He has made an outstanding name for himself at Cornell through his many activities. Rich has been treasurer of Quill and Dagger, president of Pi Delta Epsilon, and a member of Chi Epsilon (CE honorary) and the Rod and Bob Club (CE social group). He has been on the Campus Life and Radio Committees of C.U.R.W., a Frosh Camp Counselor, and president of Sigma Phi fraternity.

This makes it appear that Rich would have little time for himself, but somehow he has managed to develop and keep an interest in the outdoors. He particularly likes skiing, fishing, boating, and traveling.

The immediate future is all planned for Rich. He has been a member of the Cornell Air ROTC and, upon graduation, will become a Second Lieutenant in the USAF. After his service, Rich hopes to work either in a construction company or in civil engineering research and development.

GEORGE SUTTON ME '52

George Sutton, retiring managing editor of the ENGINEER, graduated in 1945 from Brooklyn Tech, where he was active on high school publications. He enlisted in the Merchant Marine, but decided later that he'd rather have his feet on *terra firma*. He joined the Army and was stationed at Okinawa with the 8th Air Force. He got out of the Army in January, 1947, and with the aid of the GI bill and three scholarships entered Cornell in September, after spending the summer as a swimming instructor at Budd Lake, N. J. He became a member of the Philco Co-op Plan and alternated semesters working as a draftsman and studying. He became a member of Tau Delta Phi Fraternity and was secretary and president of that group. Besides working for the ENGINEER, George found time to serve as a member of the IFC scholarship committee and as chairman of the student elections committee. At present he is a member of Atmos Club, the '52 Alumni Council, the Senior Week committee, and no less than seven honoraries: Quill and Dagger, Tau Beta Pi, Phi Kappa Phi, Pi Tau Sigma, Kappa Tau Chi, Pi Delta Epsilon, and Mu Sigma Tau.

George's hobbies are tennis, swimming, photography, and paint-

(Continued on page 60)

These five "retiring" people are George Sutton and Rich Chittenden, seated, and Bob Critchfield, Tom Foulkes, and Stan Cohen, standing. Ted Blake is absent.

EDUCATION FOR COLLEGE

A TAU BETA PI ESSAY

By PAUL SZASZ, EP '52

Colleges, especially technical colleges, have recently been exposed to a considerable amount of criticism from several sources including the press, many educators, certain members of the public, and internally from many students, faculty members and alumni. The complaints range from the alleged and proven ignorance of a great bulk of the college students of the basic facts of regional and world history and geography to their inadequate ability to use their own language effectively in speech and about the impostion of an extra year to the former four year engineering curriculum which was added ostensibly to permit them to take more broadly cultural courses.

Many others are unhappy about the several mass elementary introductory courses that they must take particularly in the so-called non-technical faculties. The professional educator is troubled by the difficulty most new students have in adjusting themselves to the load of college work and about the relatively large number of students, who, failing to make the adjustment within the allotted time, must ultimately be dropped from the college.

Although these problems appear to be entirely distinct and susceptible to solution along entirely separate lines, it is probably more useful to consider them all as aspects of a single problem of which these are but the symptoms. The basic problem is the immaturity of the students who enter the college—an immaturity that is not characteristic of their youthful age but of their incomplete educational and intellectual development. The bulk of the students are not ready for what college has to offer to them, and in particular they are not ready for what the college should be ready to offer to them if they were to keep their educational level undebased.

There are two ways in which colleges could move to meet the principal problems. These may facily be distinguished by saying that one of them involves the adjustment of the curriculum to the deficiencies of the students, and the other involves the training of the students to benefit from the undiluted curriculum. Most colleges have adopted the former method. They offer compulsory freshmen English composition courses and introductory courses in mathematics and the other basic tools of scientific and intellectual inquiry; to meet the criticism of overspecialization and ignorance of matters of basic importance to every citizen and they offer a number of fundamental survey courses, again compulsory, for they mistrust the ability of students to choose such courses for themselves according to their own inclination; finally they arrange for special lecture series and orientation programs—all in attempt to arouse intellectual curiosity in an inert mass of students, rather than arrange the curriculum to satisfy intellectual needs that had previously been awakened. In order to do all this, and still give each student a sound basic technical training, and a certain amount of advanced specialization, they have been forced to expand their courses both in length and in breadth, until the very work acts as an inhibitor rather that as a stimulant to independent intellectual activity. In other words colleges have set themselves the difficult task of simultaneously providing the student with an excellent technical education and a patchwork of culture or learning designed to cover rather than fill the gaps in their knowledge.

Yet there might be an alternative method of meeting this problem which would involve the training of the student to make the proper use of a college education independently and from the first day of his freshman year. It might be objected that this is on the face of it impossible since it appears to involve training the student before he even enters college. But it must be remembered that college is definitely not the first educational experience that students are exposed to, but rather it is the culmination of a period of training that has continued for twelve years before the freshman ever enters college. If it can truly be said that the majority of students entering college are unprepared for the intellectual effort that they will have to make there, the blame for this must be laid at the door of our institutions for primary and elementary instructions, the Public School and the High School. During the twelve years that most students spend in these schools it is expected that the student will have: (1) acquired the basic tools for intellectual inquiry; (2) received an education in the fundamentals of the democratic process, including the basic understanding of politics, history, geography, economics, etc. that will enable him to make intelligent decisions as a voter and participant in civic affairs; (3) the fundamental training in the work which he shall pursue immediately upon leaving the school, whether that work be in business, industry, or in college, and (4) an aroused intellectual curiosity which will carry over into the next stage of their life, whether

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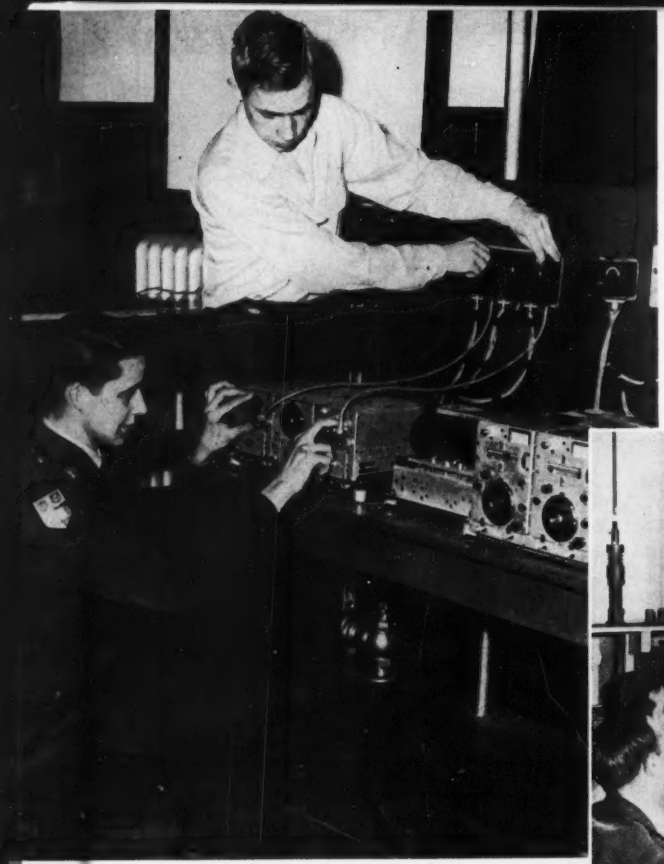
ENGINEERS

During the past few years the Reserve Officers Training Corps program has grown tremendously because of the increased need for officers in an expanded Armed Force made necessary by this turbulent world situation. The planners of our Armed Forces



Above: Robert Kormandy and John Angus, AFROTC Communications Cadets, adjust calibration on an aircraft radio set used for air-to-air and air-to-ground communication.

Above: Lt. Col. Warren instructs a Signal Corps class in the basic theory of radio with the aid of a working breadboard model.

Left: NROTC students Don Glickman and Skip Grevatt examine a scale model of a fire-room of a battleship engineering plant.

IN ROTC

By Robert M. Stuckelman, EE '54

recognized a large officer potential in the future college graduates of our country, and therefore offered to those students interested in the ROTC program the opportunity to join it.

The present program permits students to obtain

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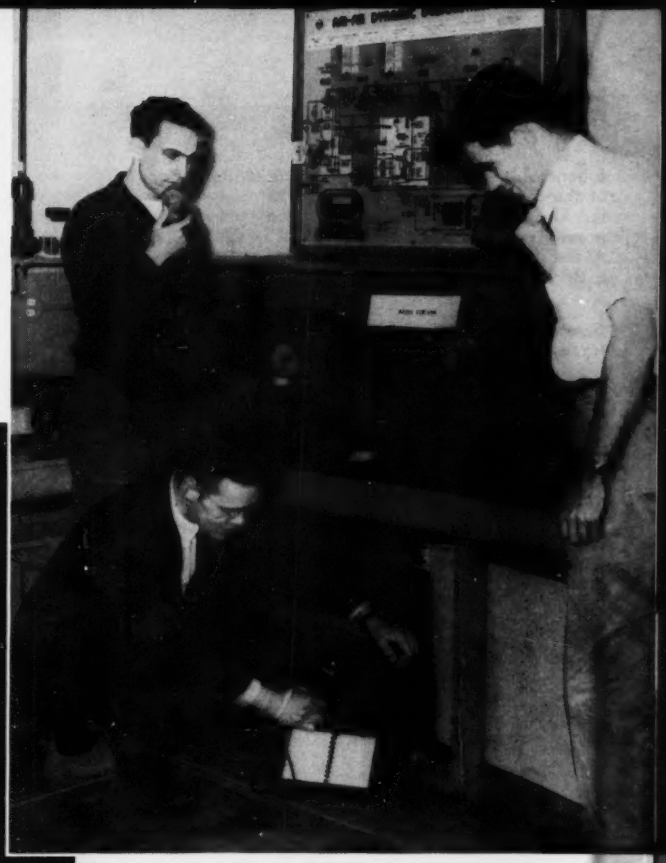
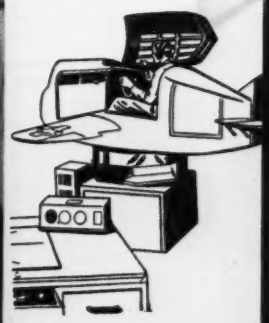


Above: Edward J. Watson talks into a transmitter as John Moyer checks the set's frequency; meanwhile, Maurice Grenoble listens on a walkie-talkie. The action takes place in an Army Signal Corps class.

Above: Air Force Communications student Charles Juran records data as Mark Myers tunes a radio compass normally used for radio navigation of aircraft.

Right: Major Weiner uses a training board to explain the operation of a retractable post rocket launcher to Air Force Armament students Kenneth Barney, Elmer King, and Glen Ostrander.

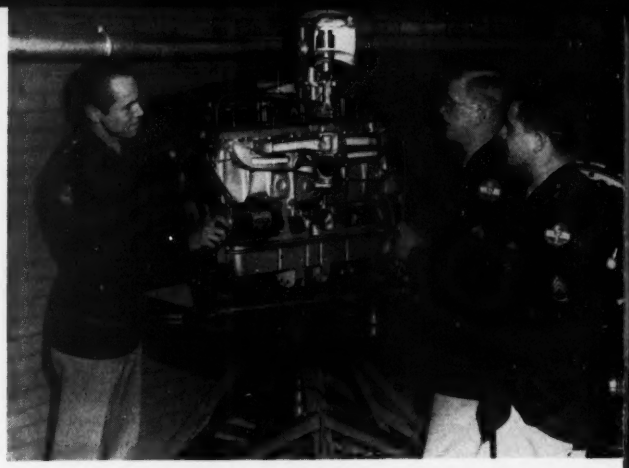


Engineers In ROTC

a general technical education in the operation of one of the three major branches of the Armed Forces—the Army, Navy, or the Air Force—and then to go on to some specialized field within one of these branches. At the same time he pursues his normal course toward a University degree.

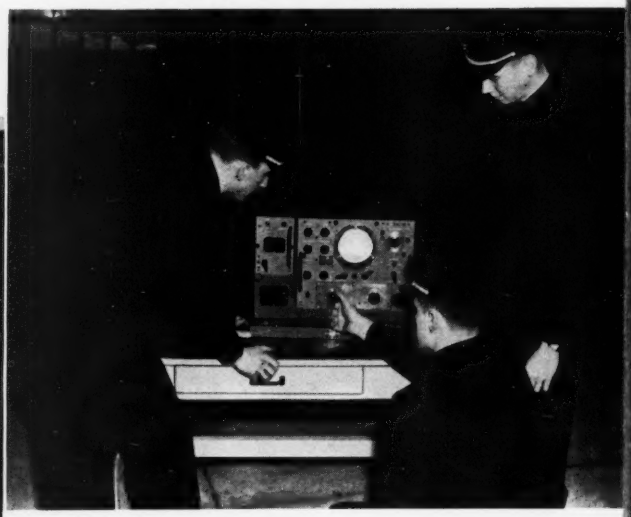
At Cornell, the Army's program includes the Signal Corps, Ordnance, Field Artillery, Quartermaster, and the Veterinary Corps. The Navy offers training toward commissions in the Line and in the Marine Corps, and the Air Force enables students to specialize in Communications, Armament, Flight Operations, or Administration and Logistics.

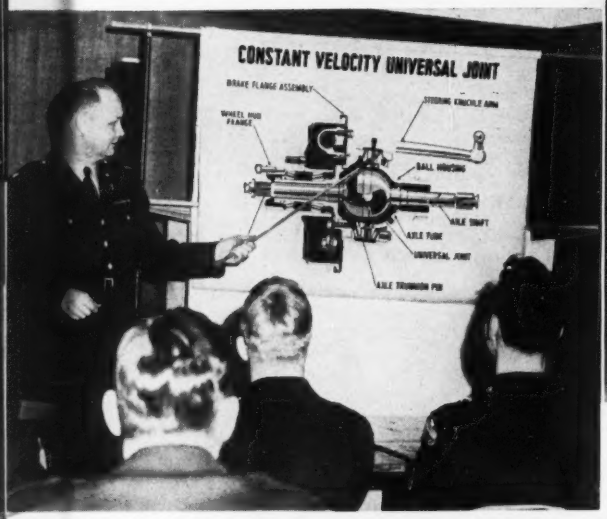
The fields of main interest to engineers are the Signal and Ordnance Corps in the Army, the Navy's Civil Engineering Corps and technical courses in the Line program, and the Air Force's Communications and Armaments Departments. The pictures on these pages show the types of training the students are given and some of the equipment available for their instruction.



Above: Cadets William Kampf, Robert Strehlow, and Steven Wallman examine a cutaway of a Chevrolet engine as part of their Ordnance training program.

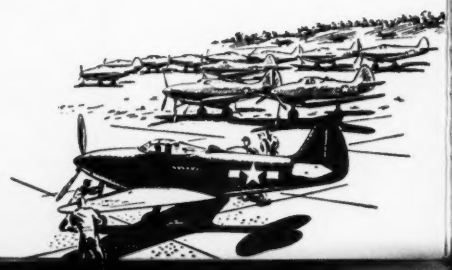
Below: Marv Anderson adjusts a Loran set during navigation instruction as Dick Cavicke and Charles Rodes look on.





Above: Major Nelson instructing an Ordnance class in the operation o a constant velocity universal joint.

Below: William Heinsohn, Richard Lofberg, and William Zwigard examining bomb fuses in an Army Ordnance Class.



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BOOK REVIEWS

Chemistry of the Silicones
Automatic Feedback Control

AN INTRODUCTION TO THE CHEMISTRY OF THE SILICONES, by Eugene G. Rochow. 2nd edition. 213 pages. John Wiley and Sons, Inc., New York, N. Y., 1951. $5.00

The versatile silicones are receiving more and more attention as special oils, greases, rubbers, and paints for severe, high-temperature service where other materials fail. They remain relatively high-priced, but apparently many modern design conditions are demanding their use, since their production is increasing at a remarkable rate.

The author of this book received his bachelor's degree in Chemistry from Cornell in 1931 and remained to obtain a Ph. D. in 1935. His thesis subject was closely related to the silicones and his early work at the General Electric Company led directly to their industrial development. This wealth of experience is one of the reasons for the authoritative presentation of his subject.

The second edition of this book is a marked improvement over the first edition. The subject matter has been expanded from 137 to 213 pages. Much new material has been added, including an excellent chapter on the physical chemistry of the silicones, and revisions have been made throughout the book to bring both subject matter and references up to date. The discussion of the uses and properties of the silicones suggests many interesting and important applications of these materials. A new chapter gives the properties of the various commerially available silicones in convenient tabular form.

The first edition was published in 1946 and suffered from wartime restrictions on the quality of paper. The second edition is completely different in this respect. Quality of paper, type, and style are excellent.

The first few chapters introduce the reader to the basic chemistry of these unusual materials. Then laboratory and commercial methods of preparing raw materials, intermediates, and finished products are discussed. Uses and properties are treated in detail and a separate chapter on methods of analysis is included.

The book is written for chemists and chemical engineers who have a good background in chemistry. A thorough knowledge of chemistry is required to understand much of the subject matter, but engineers will find the book useful as a reference that presents and discusses uses and properties of these important materials.

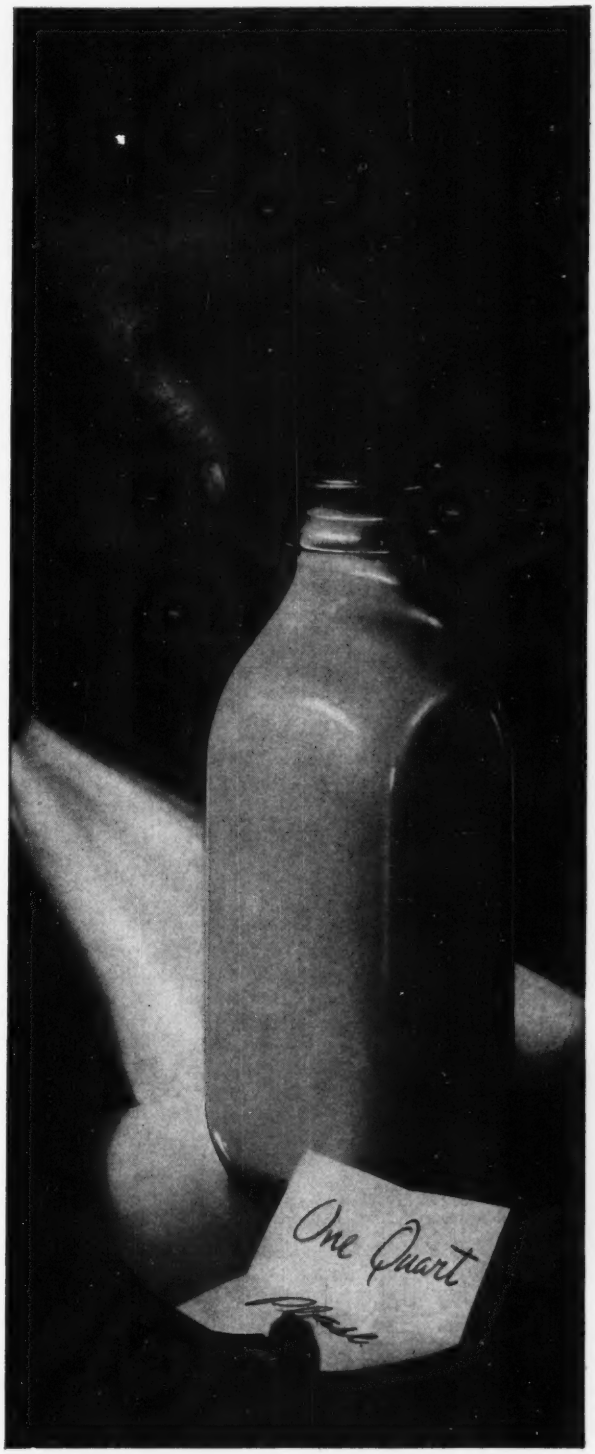
Chas. C. Winding
Professor of
Chemical Engineering

AUTOMATIC FEEDBACK CONTROL, by William R. Ahrendt and John F. Toplin. First Edition. McGraw-Hill Book Company.

The first six chapters of this excellent text on automatic feedback control were privately printed by the authors in 1946 under the title "Automatic Regulation" and are concerned with the general principles and theory of the subject. The field of feedback control systems has reached its present state of advancement through the work of many diversified groups isolated from each other by the apparent difference in the physical nature of their problems. The authors of this book have done an excellent piece of organization in developing the general theory applicable to all groups, which is followed by examples of application employing electrical, mechanical, hydraulic and pneumatic systems, or combinations of these. The book is one of the first in the field to use the recently recommended AIEE-ASME-ASA symbols and terminology, for which the authors are to be commended.

The introductory chapter discusses the broad significance of feedback control throughout nature and human civilization and is followed by an excellent chapter on the dynamical analysis of physical systems. The text presupposes a working knowledge of differential equations, but the treatment concerning the setting-up of the equations is sufficiently clear that one with little work in this branch of mathematics should experience no difficulties. There is included a good, concise treatment of the Laplace Transform method

(Continued on page 54)



5 a.m.

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Engineers' Day — 1952

The Campus will be treated to the Biggest and Best Show yet produced in the Engineering Schools

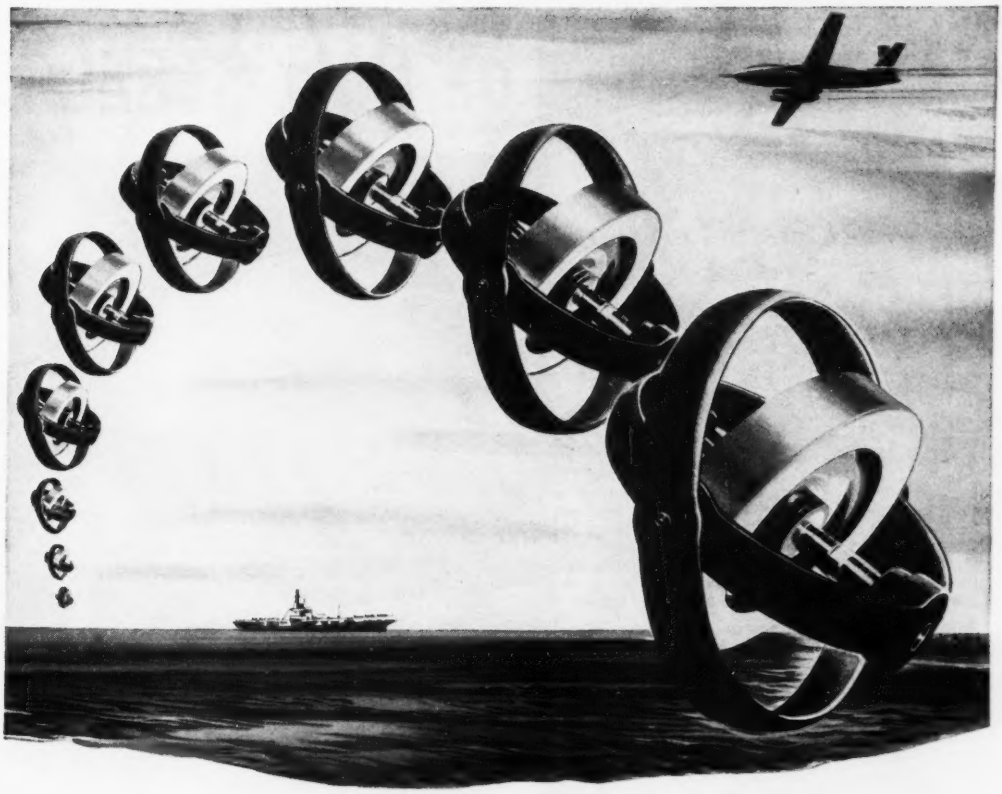
The return of spring to the Cornell campus is heralded not only by the pigeons on the Goldwin-Smith portico and the swimmers in Beebe Lake, but also by the only day during the year which is devoted specifically to engineering—E-Day.

The fourth post-war Engineer's Day, sponsored by the Cornell Student Engineering Council, will be held this year on Friday, April 25 and promises to be more entertaining than any previous program. Again, as was done last year and in pre-war days, it will be run in conjunction with Cornell Day when the campus will be thrown open to high school juniors and seniors brought to Cornell by Alumni "chauffeurs". Over two-hundred sub-frosh, many of whom are now studying here as a direct result of what they saw during E-day, 1951, visited the various engineering buildings last year.

This year, the students of the College of Engineering are planning to stage the biggest and best exhibition of their talents, that the campus has yet been treated to. In addition to the standard exhibits and demonstrations which are being repeated by virtue of their popularity at previous shows, guests will also observe many original projects that are now being whipped into shape. On view again will be such favorites as the three-story unit operations laboratory in chemical engineering; a revolutionary new method of soil solidification developed in the C.E. School; all the equipment in the mech labs and the materials processing shops; an airplane gun turret in the E.E. servo-mechanisms lab; and, if it is available, the powerful synchroton of the Laboratory of Nuclear Studies. These, and many other exhibits of special and general interest, will be demonstrated and explained to visitors in an effort to show what the students and faculty are doing within the confines of the

(Continued on page 48)

Genuine interest is shown by Prof. Katz and daughter as they view a cut-away model during Engineers' Day, May 1949.



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Sperry sponsored the development of the klystron tube — the first practical source of microwave energy. From Sperry pioneering have come a complete line of Microline* instruments for precision measurement in the entire microwave field.

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Employment Section 1 A 5

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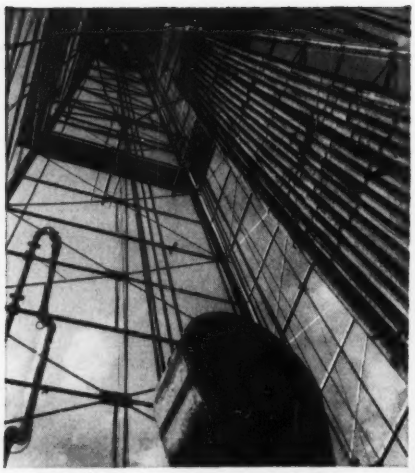

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Air Pollution

(Continued from page 18)

The disadvantages of the energy transmission systems are:

The possibility of deposits forming on the lenses of the receiving and transmitting elements, affecting accuracy and necessitating periodic cleaning of the equipment;

The decrease in sensitivity of the photoelectric tube, if one is used, necessitates continued calibration of the apparatus.

The advantages of the energy transmission method are as follows:

They provide a continuous record of smoke concentration which can be automatically recorded for future reference;

The systems are reasonably accurate and sensitive to small changes in smoke intensity;

Signals or control devices can easily be incorporated in the system if desired.

Control of Air Pollution

Operating in conjunction with the smoke control devices are the smoke-prevention systems. After the smoke has been detected and measured, the important thing is to take corrective measures.

The best method, from all viewpoints, is to eliminate the smoke directly at its source. In most cases, the presence of smoke means inefficient combustion, clogging of gas passages, and resulting increased maintenance costs. The smoke can generally be eliminated, or greatly reduced, through the manual or automatic operation of accessories in response to signals from smoke-detection instruments. Blowers, drafts, steam-jet valves, and fuel controls can be adjusted to obtain minimum readings on the measuring devices, thus reducing fuel and maintenance costs.

The collection of particles by electrostatic means is a very efficient method of eliminating air pollution. The electrostatic precipitator (Fig. 2) consists of a series of long, fine wires placed parallel to flat plates, and maintained at a high potential (up to 50 kv in large units) with respect to the plates. When air or gas is passed over these wires and plates, and through the electrostatic field produced, the foreign particles obtain a positive charge. Next, the air is passed through a series of plates alternately charged positive and negative. The charged particles, in passing through this series of plates, are repelled by the positive plates, where they cling until the plates are cleaned. In small units, the plates need cleaning out every three to six weeks, depending on the operating conditions. Cleaning is simply done by flushing the plates with water and washing the particles away. In units of about 40,000 cubic feet per minute, cleaning is automatic in alternate units. Precipitation is continuous, and shut-

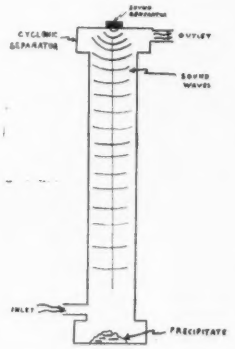


Fig. 3. The sonic precipitator utilizes sound waves to rid outgoing smoke of undesirable particles.

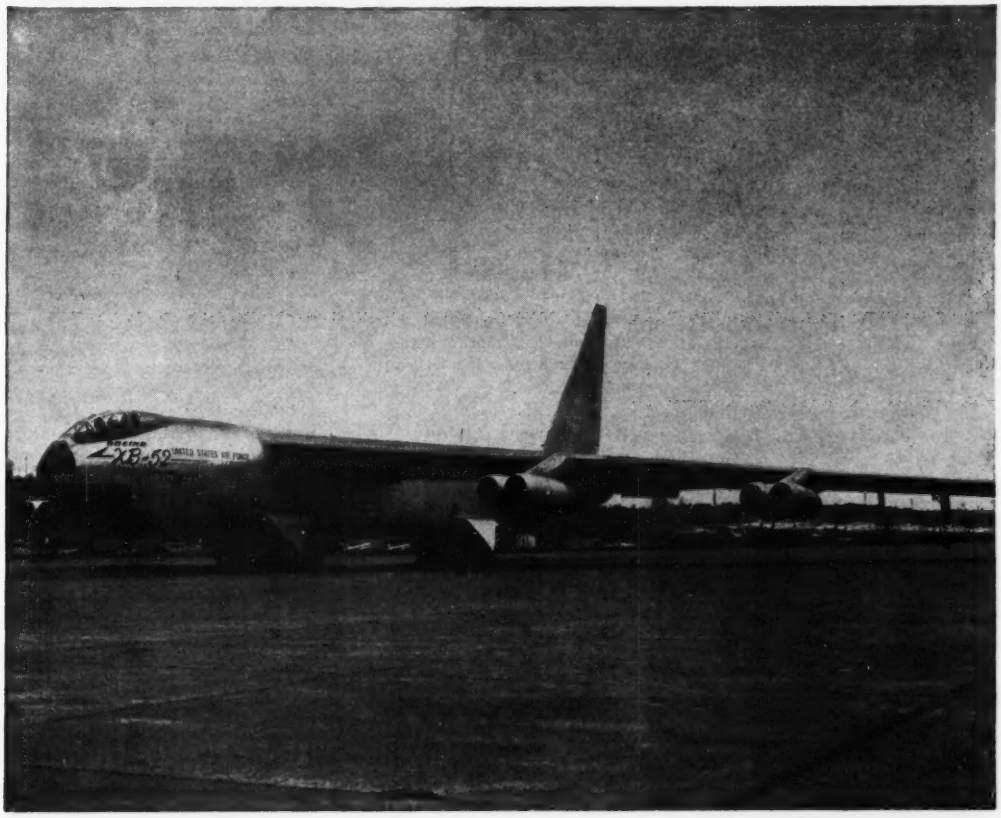
downs are eliminated. The efficiency of electrostatic precipitators is about 90 to 99 per cent in removal of almost any foreign matter, even bacteria, which makes the precipitator useful in the food industry. The electrostatic precipitator will not remove lint. Lint, when attracted to the plates, has a tendency to stand on end. Small chains of these particles reach outward from the plates and cause voltage breakdown in the unit. To avoid breakdowns, screens to remove the lint are placed in front of the precipitator.

The power consumption of an electrostatic precipitator operating under normal conditions is about 15 watts per 100 cubic feet per minute passed through the unit. Often, the cost of the unit can be defrayed by the value of the materials such as catalysts, metals, acids, and carbon black, which are recovered in the precipitator.

Sonic Precipitation

Another method of precipitating foreign particles is through the use of sonic power. Sonic precipitators are designed in the shape of a tower in which the gas enters at the bottom, leaving at the top. During its passage through the tower the smoke is subjected to high-energy sound waves. These waves cause the particles in the tower to vibrate, and because different size particles vibrate at different speeds, collisions occur. Another action causing collisions is the Bernoulli effect of the sound waves as they move between the particles. The velocity of the gas is greatest between two closely-spaced particles, causing a pressure drop, and therefore a force, tending to push the particles together. When the particles collide, the liquids join completely and form one large particle, while the solid ones tend to stick together, especially if dampened slightly during the process. On top of the tower is a siren, powered by a gas turbine, to provide the energy for precipitation. The power needed for sonic precipitation is considerably less than that for electrostatic precipitation, being about three-fourths horsepower per 100 square inches of cross-section. At present, two sonic precipitators are in use, one for sulfuric acid, and the other for soda-ash. Collection of particles is at the bottom of the tower, for large particles which drop down, and through the use of a cyclone separator at the outlet of the system.

Detection, measurement, and control of air pollution are important to industry in relation to smoke ordinances, public relations, and economics. Each of the methods of detection and prevention mentioned here is applicable to industry, but no one method will work for all cases. Each case of detection and prevention has its own special problems, meaning superiority of one system over another, and it is up to the concern to choose the best type of equipment to use.



Engineering secrets are under her skin

This is the first official photo of the giant Boeing eight-jet XB-52. It's America's new all-jet heavy bomber, and another trail-blazing product of Boeing engineering leadership. Still highly classified, Boeing's most revolutionary developments are out of sight, under the XB-52's gleaming skin.

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TECHNIBRIEFS

New Radiac Devices

A special age requires special instruments. Several types of radiation-detection (radiac) devices have already appeared as a result of both the peaceful and military aspect of nuclear energy. Two portable types, each completely self-containing and weighing about 11 pounds, are being developed for the Army and the Navy. One employs the ionization principle, as "distinguished from the familiar" Geiger counter. This type of radiac gives a true measure of Roentgen energy from 0.08 to 2.0 million electron volts over the entire spectrum—which the Geiger type can-

not do. The new instrument has the extraordinary range of six decades, from 0.005 Roentgens per hour to 500 Roentgens per hour, which latter extreme intensity might follow an atom-bomb disaster. The readings are provided as indications on a special change-scale instrument, not as clicks heard in earphones. Although the range is extremely broad, the accuracy is as good at the low settings as the higher ones. The electrometer principle employed has a longer time constant than other principles, which means the indications are not quite as rapid.

The other portable radiac employs a newer principle—developed by Westinghouse Research Laboratories—that of photoelectric detection and multiplication of the light given off by phosphors struck by the nuclear radiation. It is a little faster in response than the ionization-chamber type and is very easy to use; its warm-up time is less but it is not as sensitive. It is direct reading for the four higher ranges—from 0.5 to 500R per hour.

Another type of radiac still undergoing development is a compact unit for installation in military planes. It will give the pilot a visual indication of danger, should his plane enter a zone of strong radiation.

Self-Heating Ignition

Recent investigations by the fire protection laboratory of the National Bureau of Standards have provided conclusive proof that closely-packed fibrous materials can ignite by self-heating. NBS tests show that these materials in quantity, after standing for some time, may develop an internal temperature higher than the surrounding or ambient temperature. The extent of this temperature rise depends upon the material, its density and packing, and upon the ambient temperature and the length of time this state is maintained. This work thus gives strong evidence that suitable precautionary procedures should be taken in the storage and use of such commodities. For instance, a 12-inch cube of wood fiberboard kept at 147°F develops a peak interior temperature of 148°F; a sample kept at 210°F develops a maximum internal temperature of 230° F; and a sample at 240°F develops a temperature of 305°F. If the size of the specimen is increased, the amount of self-heating is increased.

During the investigation of the cause of the fires, the possibility of ignition due to self-heating was considered.

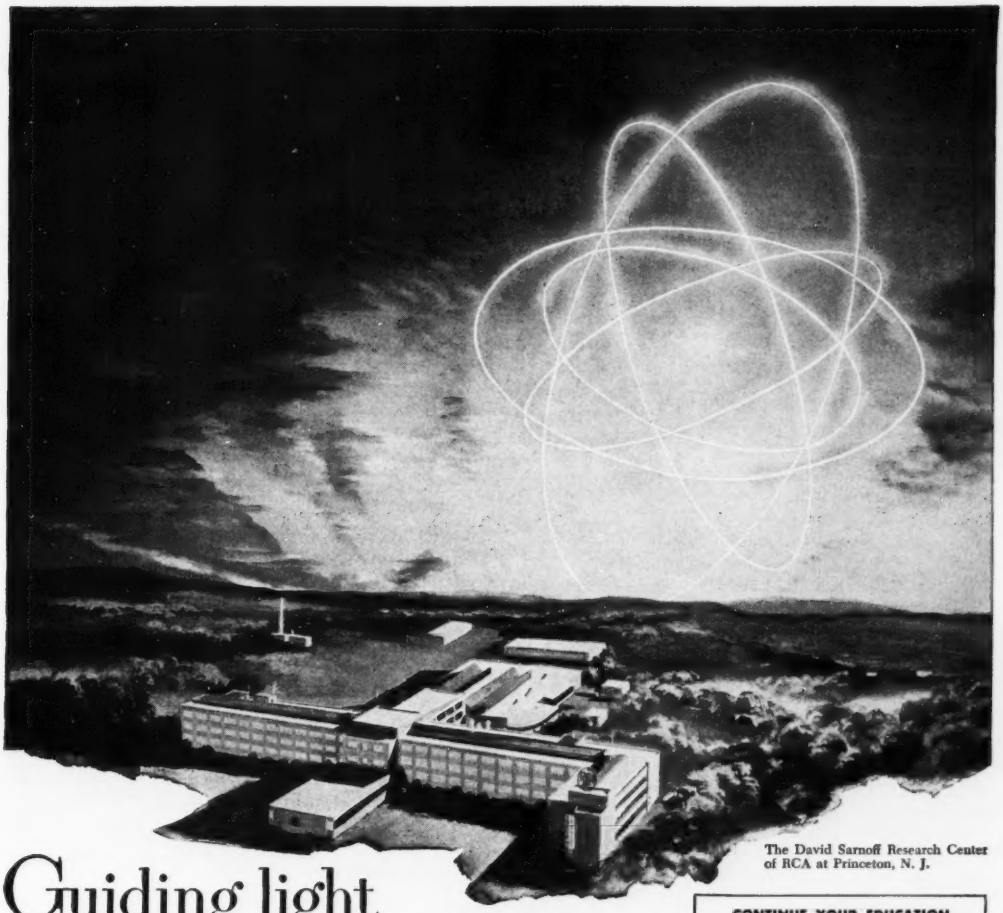
Equipment and methods for studying self-heating characteristics over a wide range of size and temperature conditions were developed. Boards cut octagonally were stacked in depths equal to the width of the octagon. These were introduced into a suitable oven or furnace and held at constant ambien temperature until the peak of self-heating was passed or until the self-heating had resulted in ignition. Series of increasing ambient temperatures were used until the lowest ambient temperature at which ignition would occur was found.

The initial tests were made of wood fiberboard specimens .01 to 12 inches in diameter. It was found that the larger the volume of the specimen, the greater is the self-heating temperature rise within the specimen for a given ambient temperature and the lower is the external temperature required to initiate combustion. Ignition started at the geometrical center of the specimen and spread outward through the remainder of the material.

Data were also obtained on cane fiberboard, felted cotton linters (alpha cellulose), Douglas fir, crushed coal, and alfalfa hay. For the cellulose-type materials tested, the lowest ambient temperatures that cause ignition fall within a range of 50 degrees F for a given sample size, but the times required to reach ignition vary widely. Thus, a 2-inch sample of wood fiberboard at 356°F ignites in 18 minutes, while a 2-inch sample of felted cotton fiber ignites at 394°F after 63 hours. When the ambient temperature is allowed to rise with the self-heating of the specimen rather than being kept constant, ignition is accelerated.

For a given material, the logarithm of the ignition temperature was found to vary inversely as the logarithm of the specimen size. It appears probable that extremely large volumes of fibrous materials will ignite at relatively low ambient temperatures and that a potential fire hazard exists in the transportation and storage of these materials —in particular, immediately after hot processing and drying. More effective control of shipping and storing temperature and of stack size is therefore recommended to reduce the probability of ignition due to self-heating.

(Continued on page 40)



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Loudspeakers

(Continued from page 14)

a folded horn of equal power output capabilities and frequency range. It should be remembered, however, that for equivalent response at a given low frequency near cut-off, the bass-reflex cabinet may be made considerably smaller, and thus cheaper, than the totally enclosed type.

As has been noted, it is possible, by using the Klipsch system, to produce a folded horn having approximately the same overall dimensions as examples of the other two systems having equivalent frequency and power output characteristics. Given a required low cut-off frequency, if the Klipsch system is not used, the preference from the point of view of size would usually be for the bass-reflex, totally enclosed, or horn-loaded systems, in that order. In connection with dimensions, it is well to mention that both the Klipsch and the other horn-loaded systems are designed in general for use only in a corner of a room, and thus are occasionally unsuitable for use.

From the viewpoint of appearance, there is little to choose between the three systems, unless there is some peculiar undesirability attached to a corner speaker. All three types of enclosures are adaptable to a wide variety of decorative schemes.

Design and Construction

Since many audio enthusiasts find it both necessary and enjoyable to build their own equipment, it is well to compare the relative difficulties involved in the design, construction, and adjustment of the three enclosure types. For the same reason that it is the most expensive of the three types, the Klipsch-type horn is the most difficult to construct. Furthermore, its design for use with a given speaker and standardized procedure of no great complexity in which experience is nearly always essential if good results are to be obtained. At the other extreme, the design of totally enclosed baffles is a thoroughly standardized procedure of no great difficulty. Moreover, with this type of cabinet, no adjustment is required and construction is the simplest of the three, since the cabinet is essentially a padded air-tight box.

The bass-reflex type enclosure presents only slightly greater difficulties in design and construction than the totally enclosed type. Both design and construction principles are fairly well standardized. It must be admitted, however, that there is considerable disagreement among authorities in connection with the matter of adjustment of reflexed cabinets for optimum performance. In general, adjustment is essentially a tuning procedure, governed usually by adjustment of the dimensions of the port. Disagreement arises, however, as to the best means of determining when proper adjustment has been obtained. Although one authority states that it is practically necessary to have the use of anechoic room and associated equipment, the author has found that the use of the Worden adjustment procedure appears to give satisfactory results, both in obtaining a smooth impedance characteristic and optimum damping at the frequency of fundamental resonance.

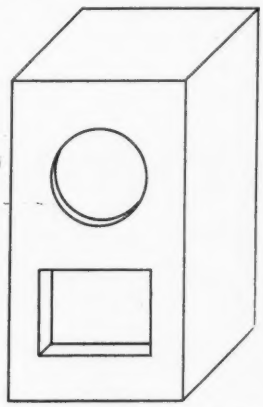

Fig. 4. Appearance of reflexed cabinet ready for installation. Upper section contains the speaker with port directly below.

In summary, the author believes the bass-reflex enclosure to be the most satisfactory for general use in quality domestic sound systems, where cost is a limiting factor. However, in home systems of the highest quality, the Klipsch-type folded horn is probably the most desirable.

Technibriefs

(Continued from page 38)

New Vehicle

A new vehicle which operates like an Army tank has been developed by General Electric Company engineers at Erie, Pa.

Equipped with treads similar to those of an Army tank, but having a lower silhouette, the "shuttle car" is powered electrically, and its "extension cord" or power cable is plugged into an outlet in the same way household applicances are. The 600 feet of cable are automatically reeled in or out as the car travels.

Coal is first loaded on the car deep in a vein by miners or by automatic mining machines. Then the shuttle car carries its load to the main tunnel and transfers it to small railroad cars or belt conveyors which take the coal to the hoists or directly to the surface.

The shuttle car has a snout, which it can raise or lower, from which it disgorges its load by means of continuous conveyor belt.

Because of its treads, the new vehicle can turn in a tight circle by simply locking one track and going ahead on the other. The treads also enable the shuttle car to carry a larger load than the conventional type equipped with wheels requiring clearance pockets. In addition, the wider conveyor belt made possible by the elimination of wheels, results in faster unloading.

The vehicle can carry up to ten tons of coal. It is about 22 feet long, eight feet wide, and three to four feet high, and is built for either left or right-hand drive.

(Continued on page 44)

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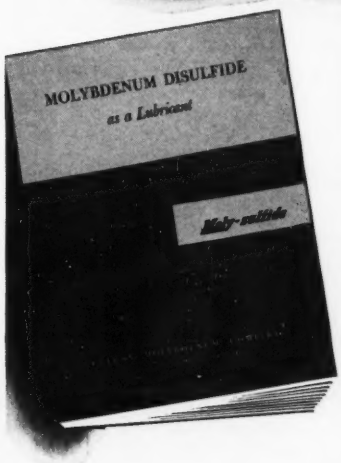

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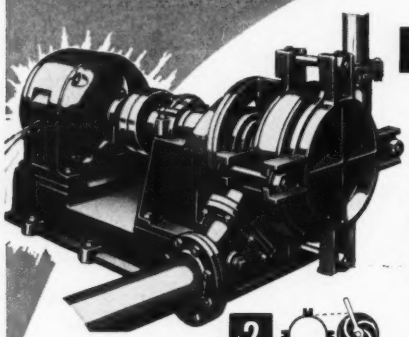

1 No internal studs or bolts — no troublesome internal joints and fits. Suction Disc Liner is merely *clamped* into position between disc and shell. Fewer wearing parts mean less maintenance and longer uninterrupted service.

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4 Hydraulic passages of the suction discs are extremely large and velocities are low. As a result, wear is minimized and renewal infrequent.

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MORRIS *Centrifugal Pumps*

Profile

(Continued from page 19)

where he has been ever since.

Although teaching keeps him well supplied with a full day's work (he now has the entire freshmen ME class in freehand drawing), Professor Baird has always remained active in his own field. He designs a home "every now and then"—mainly to keep from becoming rusty—and is deeply interested in modern art. He designs the exhibitions for the Contemporary Arts Festival at Willard Straight Hall each year and also designed part of the decor for the Cornell Dance Club concert this winter. His work has received recognition by the American Institute of Architects, which awarded him a medal for merit in design and he has published many articles.

Professor Baird's taste for the simple, practical and esthetic are strikingly demonstrated in his own home overlooking Lake Cayuga. The house, which he redesigned from a drab little cottage, is a fine example of progressive residential architecture and occupies a site which, as he puts it, "is one of those rare happenstances where Nature outdoes herself." On either side—about 90 feet apart—is a glen with a waterfall pouring down from the wooded hillside toward the lake. Recreational facilities abound everywhere — swimming, boating, picnicking, hiking, gardening and all other forms of country life. Both he and Mrs. Baird, who is on the staff of the women's physical education department here at Cornell, enjoy the outdoors and their house is designed to "let in" as much as possible the beautiful surroundings.

One interesting ramification of Professor Baird's practical nature is the beret he is often seen wearing. When asked if it carried any connotations of the artist in him, he laughingly replied that "a hat simply wouldn't stay on in a high wind. And besides you can't tuck a hat in your pocket when you decide you don't need it." Seriously though, it demonstrates in its own way how his scheme for living has been based upon the simple, functional necessities for a happy and comfortable life.

"No mud on *our* Pulpit!

"No . . . not in our *little church!*

"But something the Pastor said reminded me of a service I'll never forget. Later, Helen told me I'd said *'Mud!'* out loud. That's why she dug me in the ribs and said *'John, wake up!'*

"I guess I *was* wool-gathering. I was back overseas, listening to a Chaplain who'd found a spot of beauty in a grove of trees for his services . . . right smack in the middle of a war! The green branches made a church-like arch. The sun filtered through the branches like through our church windows.

"The Chaplain's pulpit? Just the hood of a homely Army Jeep . . . *splattered with mud.* No organ music . . . just the booming of big guns far off. No pews, either . . . just mud to sit in. But I felt just as close to God then as I did last Sunday in our Maple Street Church.

"After Helen nudged me awake, I thought of countries where mud *is* slung at pulpits. Where men of the cloth are jailed. Where churches are closed or burned. And where God is disowned. I gave thanks that *here* we respect *all* churches.

"Freedom of worship is *one* of our precious rights. Other Freedoms include our right to vote as we please . . . and without anyone knowing *whom* we vote for. To get rip-roaring mad when we see our taxes wasted by wild spending . . . and when we read about charges of corruption against public officials. To choose our own jobs, like I did when I applied for one at Republic. To own our own homes. To drive our own car across state lines with nobody to push a gate down in our faces.

"I said an *extra* prayer last Sunday: *May our Reverend Johnsons, Father Kellys and Rabbi Cohens always have that sacred Freedom to preach their gospel from unmuddied pulpits. Amen.*"

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Education

(Continued from page 25)

that be in school or at work.

Two objections may be raised to this point. The first one concerns the fact that the majority of students do not continue on to college and it would therefore be both impolite and impossible to demand that High Schools orient themselves further towards college preparation when such efforts would be wasted on the bulk of their students. This objection disregards the fact that three of the points outlined above are definitely not college preparatory but are rather life preparatory and should apply with greater force to those students who are about to terminate their formal education, and assume the duties of citizenship and of humanity without the benefit of further intellectual training. Only when it is insisted that students also learn the tools of intellectual pursuits could this objection be conceivably valid, for to one who does not intend to use them these tools are not only useless but generally much more difficult to acquire. Here the only answer that one can give is that it will be necessary to make some distinction on the High School level between those students who intend to go to college and those who intend to work. Such a distinction is already made in many schools and is in fact frequently drawn to a much finer degree in schools where the pupils by electing individual courses or particular course sequences can actually prepare themselves for a particular kind of industrial or office work. If it is objected that such a distinction would be undemocratic it should be noted that the separation is not based on economic or social factors but simply on use that a student wishes to make of his primary education. Since all of us are not preparing to fit ourselves for the same career some preparation of intellectual and practical application must be made at some point—it appears to be too late to make it at the end of the twelfth year of education.

The second principal objection is probably more practical: Even if colleges would like to see the entering freshmen better trained, more ready to assume the burdens of work that are about to be placed on them what can the colleges do to obtain such pre-trained candidates? In other words what can colleges do to induce the lower schools to train students to their prescription? There would appear to be three principal paths that can be used and all of them should be explored simultaneously and to a greater extent than at present. (1) Since the bulk of the intellectual and even of the political leadership of the nation comes from among college trained men, it is necessary that students while they are at college be inculcated with an educational philosophy that will make them work for and demand high standards when they find themselves in position of some influence or authority, whether that be in the legislature of a state or of the nation, or on the local school board. (2) The Presidents and the staff members of the large Universities should employ their considerable prestige to advance the cause of primary education in the United States; in many ways this matter is even more vital to them than a supervision of the quality of their own institution since the raw material for their schools comes from below. (3) Admission standards should be raised gradually and in concert, thus forcing the lower schools to conform to higher standards demanded if they wish their students to enter the more desirable educational institutions.

These several steps may appear to be somewhat drastic or politically unfeasible. It should be remembered that what is desired is a gradual change, to be accomplished by persuasion and by the sanction of public opinion. In their concern to make the financial ends of their college meet and suffering from the usual timidity of the academic man in the face of politics, the leaders of our great institutions of higher education must remember that in a democracy the adequate standards of the schools that the bulk of the people attend is of primary importance to their own institutional survival.

Technibriefs

(Continued from page 40)

Drive For Rolling Mill

A special electric drive, largest of its kind, is being built by the General Electric Company for a giant rolling mill that holds a world record for squeezing five-ton blocks of white-hot steel into long iron bars, called "blooms."

Designed to keep pace with the demands of a steel-hungry defense effort, the equipment will constitute the nation's most powerful reversing mill drive for converting ingots into blooms. It will include twin 6,000-horsepower motors, each of which will drive one of the mill's two huge pressure rolls.

Steel ingots, five-foot-long masses of metal weighing as much as three medium-sized automobiles are heated to 2200 degrees F as raw material for the mill. As an ingot passes back and forth between the rolls, it is reduced to a bloom more than 50 feet long and seven inches in width and thickness. These blooms are later rolled into steel products in the various finishing mills.

The main drive motors for the mill will be provided with amplidyne control for near-instantaneous acceleration, deceleration, and reversing of the rolls. This control will permit the mill to reverse in approximately one second, G-E engineers said.

Providing power to the motors will be a 12,000-kilowatt motor-generator set, which includes a 91½-ton flywheel. The flywheel, one of the largest ever built, will be nearly 16 feet in diameter and two feet thick. Its stored energy will be equivalent to that of the full 15-car Twentieth Century Limited traveling at 40½ miles per hour. The flywheel releases portions of this energy through generators to the drive motors to reduce peak demands on power-supply lines.

To insure against breakdowns in the blooming mill's 160-hours-a-week work schedule, equipment will be so installed that near-peak proformance can be obtained even when portions of the apparatus are out of service, engineers said.

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In these many operations we require the services of all types of engineers, engaged in all phases of engineering work—from pure research to production supervision.

This work is decentralized among GM's 34 manufacturing divisions, operating 112 plants in 54 towns and cities throughout the country. Each division operates as an independent unit with its own engineering department. Yet each benefits from the resources of GM's central research and engineering laboratories.

So, from the start, GM offers the engineering graduate both the opportunities and facilities of a large successful organization, and the friendly working environment of a smaller company.

It is well, too, to note that a high percentage of engineering school graduates, through hard work and initiative, have made sound business careers for themselves at GM. In fact, today, many GM divisional managers are engineering school graduates. And so are many others in top management.

For further information on a GM engineering career, we suggest you ask your College Placement Office to arrange an interview for you with the GM College Representative the next time he visits your campus.

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CABINET MEMBER: "It should bring to light some valuable ideas which might otherwise not have been known."

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A MEMBER OF THE JOINT CHIEFS OF STAFF: "The Sinclair Oil Corporation is performing another fine public service in opening its research laboratories to the American inventor. I am confident that the nation will derive many benefits from this selfless service."

PRESIDENT OF A BROADCASTING NETWORK: "To make the magnificent facilities of the Sinclair Research Laboratories available to inventive Americans under what would seem to be a very fair arrangement is a constructive and forward-looking step."

PRESIDENT OF LARGE MANUFACTURING CORPORATION: "We all think the plan, which opens wide the doors of your great research laboratories, should indeed encourage individual inventors."

AN AIR FORCE GENERAL: "I wholeheartedly agree that there is a need to help the independent inventor because of the complexity of modern technology and the prohibitive cost of these facilities. Your farsighted plan is a great stride in relieving this situation."

PRESIDENT OF A LARGE MANUFACTURING COMPANY: "You have recognized a great need, and have done something objective to overcome it . . . another idea which puts to beneficial use the resources and capacity of a large group."

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If you have an idea for a new petroleum product— but do not have the facilities needed to develop it— the Sinclair Plan offers you laboratory help.

EIGHT months ago, Sinclair opened up a part of its great research laboratories to independent inventors who had ideas for new or improved petroleum products but who did not have the facilities needed to develop and profit by their ideas.

To date nearly 5,000 inventive people have submitted ideas to the laboratories; and the Sinclair Plan has become recognized as a service to inventors, the oil industry and the public. As a result we have made the Plan part and parcel of the long-range operation of our company.

If you have an idea for a new or improved petroleum product or application, you are invited to submit it to the Sinclair Research Laboratories. In your own interest, each idea must first be protected by a patent application or a patent.

If the laboratories select your idea for development, they will make a very simple arrangement with you: In return for the laboratories' work, Sinclair will receive the privilege of using the idea for its own companies, free from royalties. This in no way hinders the inventor from selling his idea to any of the hundreds of other oil companies for whatever he can get. Sinclair has no control over the inventor's sale of his idea to others, and has no participation in any of the inventor's profits through such dealings.

HOW TO PARTICIPATE: Instructions are contained in an Inventor's Booklet. Write to W. M. Flowers, Executive Vice-President, Sinclair Research Laboratories, Inc., 600 Fifth Avenue, New York 20, N. Y.

IMPORTANT: *Please do not send in any ideas until you have sent for and received the instructions.*

Nine buildings of the Sinclair Research Laboratories at Harvey, Ill.

SINCLAIR—for Progress

Engineer's Day—1952

(Continued from page 32)

engineering buildings. Short lectures and movies will also be presented throughout the entire program to supplement the exhibits.

The administration of Engineer's Day is being handled by a committee headed by Ted Wong, EP '53, and Chuck West, EE '53. The school chairmen are: Bob Siegfried, ME, Walt Bortko, CE, Howie Hart, EP, John Pew, EE, Bob Katz, Architecture and Al Riccardo, Met. E. Dave Scharaga, M.E. '54, is publicity chairman.

The climax to the E-Day weekend will be the Engineers' Banquet on Sunday evening, April 27, also being sponsored by the Cornell Student Engineering Council. Presentation of the E-Day awards for outstanding exhibits and of the Fuertes Memorial Public Speaking Contest prizes, will be made at the banquet, in addition to awards by several engineering honorary societies.

The CORNELL ENGINEER, on behalf of the CSEC would like to extend a cordial invitation to all its readers to come to Cornell on the weekend of April 25 and take part in the festivities. The exhibits will be open from 7:00 to 11:00 p.m. on Friday night. And don't forget the banquet on Sunday—it promises to be an enjoyable occasion.

Jumping coil experiment fascinates a young visitor in Rand electrical laboratory, May 1951.

Alumni News

(Continued from page 21)

dent since 1943. His home is at 8 Ridgewood Road, Rye, New York.

Albert J. Blackwood, M.E. '24, assistant director of research for the Standard Oil Development Company, has been appointed to the National Advisory Committee for Aeronautics subcommittee on aircraft fuels. He is also a member of the panel on fuels for air-breathing powerplants of the U.S. Research Development Board. He lives at 1005 Boulevard, Westfield, New Jersey.

W. J. Newman, B.S.E.E. '45 formerly at Davel St., Bloomfield, N.J., has been called back to active duty, and is taking a leave of absence from the Wallace and Tiernan Co. of Belleville, N. J. His present address is LTJG W. J. Newman, USS LST G11 988, Fleet Post Office, New York, N. Y.

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Aladdin and the "Al Kali"

You remember the story of Aladdin and his magic lamp. But what never came out in Arabian Nights was the probability that Aladdin might well have used "al kali" to cleanse and polish the old lamp, when he made the discovery of its magic properties.

The origin of soda ash—oldest of the major industrial chemicals—is veiled in antiquity. Its history goes back at least 5,000 years through the civilizations of many peoples. In various parts of the world the ashes of plants were leached to obtain soda. One of the plants so used by the Arabians was kali, and their term for soda, al kali, became our word alkali.

The miracles of modern industrial chemistry of course far surpass the magic of Aladdin's lamp. Many of these industrial processes and products employ alkalies to bring to our civilization a multiplicity of refinements undreamed of even a few short years ago. As one of the nation's leading producers of alkalies and related chemicals, Columbia-Southern salutes the achievements of the industries it serves.

SODA ASH—

a chemical of many uses

Although soda ash was first utilized for its cleansing powers—and soap making continues to be an important usage—other uses have long exceeded the original. Soda ash is a basic ingredient of glass, this being the largest single use; but soda ash is also essential to so many chemical processes that, in the aggregate, this is the largest market. Virtually every industry uses soda ash to some extent and the following are merely indicative of its versatility: water treatment, metals refining, pigments, pulp and paper making, textiles, petroleum refining, ceramics, leather tanning. A complete list of all processes involved would fill a good-sized book!

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Metal Transfer

(Continued from page 11)

hence the different appearance of otherwise similar particles. Some are sectioned equatorially and thus show a section of metal surrounded by slag or else a section of metal and slag intermixed. Others are sectioned considerably above their equators and show slag only. Those particles whose centers appear blurred, dark, and out of focus are the hollow ones.

The theory that gases liberated in the electrode metal, and acting in the manner described, supply the force that transfers the metal across the arc is consistent with the observed behavior in metallic arc welding. It explains the fact that metal always transfers from the electrode to the work, and never in the opposite direction. This is true regardless of what type of electrode is used, in what position the welding is done, or what type of current is used. It explains the presence of the very small particles in the arc as well as the larger ones. As the bubbles, filled with gas under pressure, burst, the particles of metal are given velocities in directions essentially perpendicular to the surface of their parent bubbles. Thus, this explains the presence of spatter in welding. Figure 1 shows this phenomenon for an uncoated electrode. The particles leaving the arc in a somewhat horizontal direction constitute the spatter. Figure 1 shows how in a coated electrode the gas stream from the weld rod coating tends to deflect the particles with initial horizontal trajectories back toward the arc, reducing spatter. This is also consistent with the observed facts. As previously mentioned in the gas stream theory, the smaller particles will be deflected more readily by the gas stream. This implies that the spatter will probably consist of particles larger than the average size transferred through the arc.

The theory is further confirmed by the work on degasified electrodes which was previously mentioned in connection with the cathode spot theory. When the gases are removed from the electrodes, overhead welding becomes impossible.

Summary

In discussing the various theories presented in this article, it was shown that all but the gas expansion theory had serious shortcomings in one respect or another. However, the gas theory is not being proposed as the ideal theory since insufficient work has been done to warrant such a claim. This theory does seem to show greater potentialities than any other, but more experimental work is needed. For example, it is believed that although the gases liberated in the electrode tip furnish the main driving force for the transfer of electrode metal, welding could be accomplished in the down-hand position with gas free electrodes. Gravity in conjunction with surface tension and pinch effects could accomplish some transfer of metal. It is postulated, however, that the arc would exhibit somewhat different behavior than in ordinary welding. A systematic study of this situation and others, employing degasified electrodes, might prove to be quite valuable in understanding metal transfer and thus in improving the efficiency and quality of arc welding as a commercial process.

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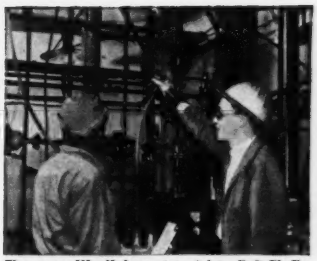
THE DU PONT DIGEST



Thurman W. Kaiser *(at right), B.S.Ch.E., Purdue '50, supervises tests of improved process for making neoprene intermediates.*

Ch. E's at Du Pont

[FOURTH OF A SERIES]

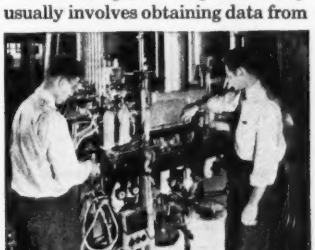
Plant development work is solid background for a future in chemical engineering

The work of production supervisors at Du Pont, as discussed here last month, is aimed at getting better results from existing processes and equipment.

In contrast, the job of plant development groups is to find ways to improve methods and products, and advise management when changes should be made for economic or technical reasons. Chemical engineers in this work are responsible for lowering process costs, adapting the product to new uses and improving product quality to obtain a larger share of the existing market.

These duties provide an understanding of the fundamental aspects of the business, as well as a broad view of Company operations. The training and experience a man gains as a member of a plant development group—often a first assignment at Du Pont—is an excellent background for any field he may move into later.

Conducting a development study usually involves obtaining data from laboratory, semi-works and plant-scale experiments, estimating profits and investments, and consulting with sales, research and production personnel, also with auxiliary departments such as Engineering, Chemical and Purchasing, and with outside authorities.



H. E. Graham, Jr., *B.S.Ch.E., Georgia I. T. '48, and J. F. Carley, Ph.D.Ch.E., Cornell '51, study a plastic compounder-extractor-extruder for improvements in making plastics.*

Here are typical problems solved by plant development groups:

John Purdom, *B.S.Ch.E., Ohio State '49, and Kenneth Kehr, B.S.M.E., North Carolina State '50, discuss diagram of a process for improved recovery of a nylon intermediate.*

1. Prompted by obsolescence and wearing of equipment, experimental studies and economic comparisons were made on the entire process of isolating dyes. Methods in use called for crystallization, filter pressing and tray drying. It was found that a rotary vacuum filter with a continuous rotary steam tube dryer, air conveyor and a dust collection system reduced costs about $50,000 a year.

2. Production of sodium silicate was to be increased substantially, but the tank-type furnace at the heart of the process proved a bottleneck. The furnace design, including exit and entry ports, was improved, and its capacity enlarged at a small fraction of the cost of a new furnace.

Reid Earnhardt, *B.S.M.E., Cornell '44, M.S.M.E., Carnegie '48, and René M. LeClare, M.S.Ch.E., M. I. T. '51, check installation of improvements in plant equipment.*

With the rapid growth of technological improvements all over the world and increasing competition, plant development work assumes greater and greater status. The Ch. E. entering such a group at Du Pont finds a wealth of opportunity for his skill and ingenuity.

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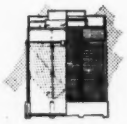

3 . . . that a Cooling Tower can be Built to Blend with a Building—or to Stand Alone against Hurricane Winds?

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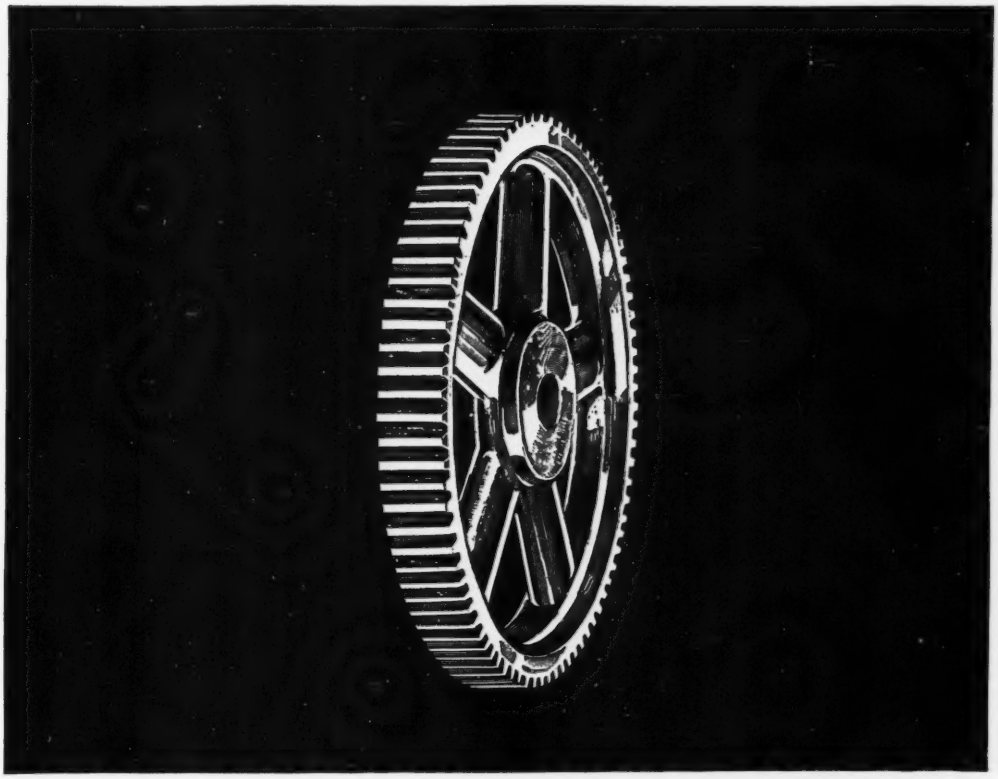

ANCESTRY UNKNOWN . . .

No one knows who first thought of gears as a means of transmitting power or motion . . . but without them modern civilization could not function.

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HEADQUARTERS FOR BUSINESS INFORMATION

Book Reviews

(Continued from page 30)

for the solution of equations. There is a particularly good presentation of the elementary theory of the functions of the complex variable. It is important that one have a thorough understanding of this in order to fully appreciate the meaning and application of Nyquist's criterion for stability.

The transient analysis of systems is presented and applied to some highly idealized linear regulatory systems such as a simple servomechanism, and a simple speed-governed system. Routh's criterion for stability is introduced as a practical approach to analytical stability considerations.

Although the transient analysis of a feedback control system gives a true and accurate picture of its behavior, the method is difficult to apply to systems of any great complexity. In such cases equations involving high powers of the transform s must be solved and thus call for laborious and time-consuming calculations. Consequently, particularly where synthesis of systems is the objective, the frequency spectrum method is employed. It is also relatively easy to experimentally verify designs when using steady-state sinusoidal quanities. The authors' treatment of this subject, including Nyquist's criterion for stability, is excellent. The book contains a very complete discussion on multiple loop feedback control systems together with their stability considerations. Minor feedback loops are well illustrated with actual physical applications. More material on design considerations employing logarithmic coordinates would be desirable.

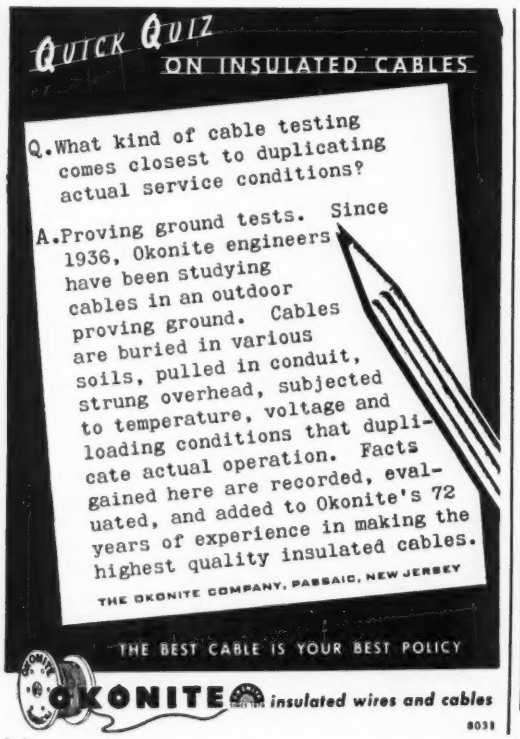
The authors are to be complimented on having included a chapter on non-linearity and discontinuity. This is the first book including the consideration of such things as friction, back lash, saturation and variable gain. In this connection there is the whole class of discontinuous controllers, which are now becoming more and more important.

The remainder of the book is devoted to special systems with applications such as servomechanisms, pneumatically operated controllers, temperature regulation, speed governing, and pressure, flow and liquid level control.

The treatment on pneumatically operated systems is the best that has appeared in any book. Equivalent resistance-capacitance circuits are developed and then transfer functions of pneumatic mechanisms are derived.

There is a good set of problems devoted to each chapter at the end of the book which greatly enhances its use as a text. This book is a real contribution to the group of college texts in the subject, and admirably adapted for use as a first text equally good for all engineers, whether mechanical, electrical or chemical.

W. E. Meserve
Professor of Electrical Engineering
(Servomechanisms)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ON INSULATED CABLES
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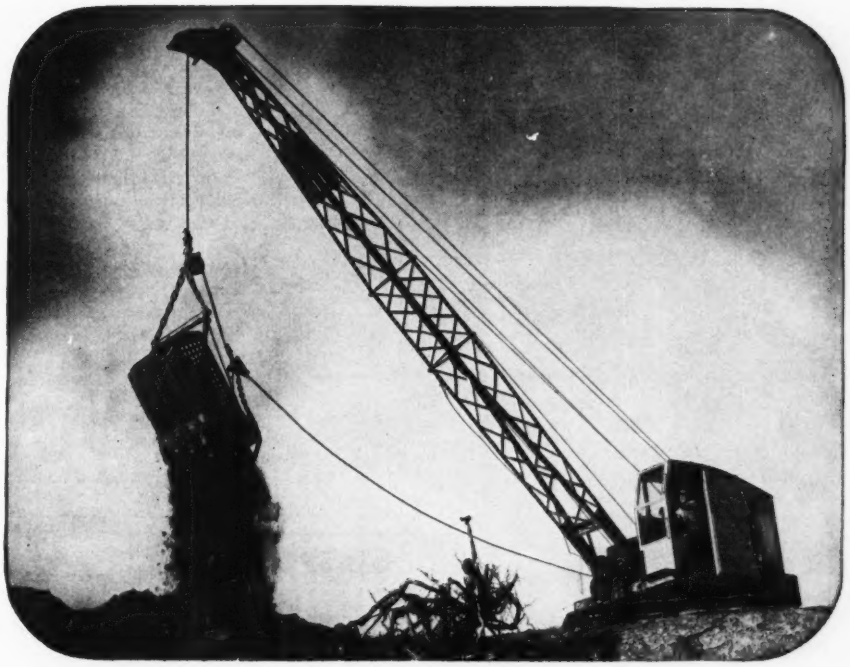

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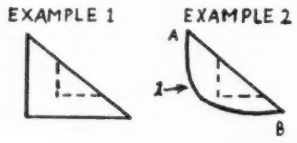
LETTERS

January Brain Teaser

U.S.S. Carmick
c/o F.P.O.
San Francisco, Cal.

To the Editor:

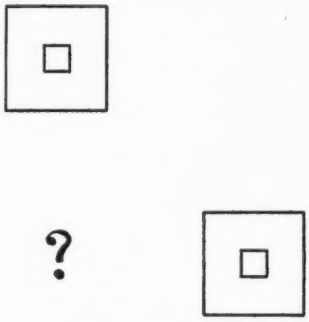
Regarding the answer appearing in the February issue of the CORNELL ENGINEER of the brainteaser appearing in the January issue, it seems that several possible solutions have been slighted, namely:



As line one (1) in example 2 can take any number of smooth paths from A to B, there appear to be an endless number of solutions.

LT. JG. D. CHULIK, '46
LT. JG. C. W. DICK, Stanford
ENS. R. A. RIECKMAN, Northwestern
ENS. H. J. NIX, Annapolis

January Brain Teaser:



(Too many college boys in the Navy.—Ed.)

Who Was He?

Hudson, Ohio

To the Editor:

Please permit me to answer the "Picture Puzzle" on page 50 of the Dec. 51 issue.

The gentleman "depicted" is Mr. Wm. E. Reed M.E. '89, same "cut" as of page 19, Vol. 10, No. 6 (Mar. '45). He was secretary of the Warner & Swazey Co. When I was a 4th year (machinist) apprentice, Mr. Reed befriended me and got me interested in Cornell, which I entered in '97, Dr. W. F. Durand, as secretary, handling all preliminary correspondence, seeing me entered, following me through the course, seeing me graduated and keeping in touch with me ever since.

On the 5th of March he was 93 years old, residing at 379 Washington Ave., Brooklyn, N. Y. since the death of Mrs. Durand, a year ago.

DAVID GAEHR

P.S. Mr. Reed was also "depicted" in his class reunion picture.

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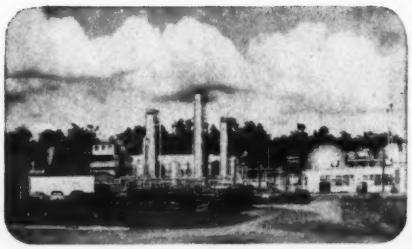

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174

Retiring Board

(Continued from page 24)

ing. Last summer he worked for the American Machine and Foundry Co., where he designed a new machine for the U.S. Ordnance Dept. George is interested in project and development engineering as a career, but right now he's looking forward to graduation and a short rest—well-earned, we'd say.

BOB CRITCHFIELD ME '53

A native of Garden City, Long Island, and a graduate of Garden City High School, Bob Critchfield came to Cornell in 1948. Bob is a rabid amateur photographer and was photography editor of his high school yearbook. He competed for the illustrations board of the CORNELL ENGINEER during his first spring at Ithaca and rose to the position of editor on that board. He has held jobs as watchman, grounds-keeper, and gas station attendant at various times during the last several years. This summer he plans to attend camp as the guest of the Ordnance division of the Army ROTC. A member of Theta Xi Fraternity, Bob is interested in singing and is one of the many fine voices in the Men's Glee Club. The song on his mind right now is probably "California, Here I Come", for Bob's family is moving to Los Angeles soon. Those who have enjoyed the interesting covers of the CORNELL ENGINEER the last year or so will appreciate the fine work that Bob has done as Illustrations Editor—a job well done.

TOM FOULKES ME '53

This year, the ENGINEER has been quite fortunate in having Tom Foulkes as its Business Manager. Tom has been one of the most active engineers at Cornell, but has found time to do a giant's share of work on the business side of the ENGINEER.

Tom came to Cornell from Brighton High School in Rochester, New York. He determined to make his stay at Cornell as profitable as possible, wanting to get as much from campus life as from his studies. This promise was certainly fulfilled—Tom's list of activities would stagger the weak-kneed. He has been a Frosh Camp Counselor, secretary of Pi Delta Epsilon (journalism honorary), and a member of Pi Tau Sigma and Kappa Tau Chi (ME honoraries). He has been elected to Sphinx Head, and has been secretary and social chairman of Alpha Delta Phi fraternity.

Tom's main interest, however, is music. In his eyes, engineering is a pretty good profession, but music is definitely his first love. Tom plays both the trumpet and piano and is in Octagon, the Big Red Band, and the Savage Club. Last year, Tom was a member of the Three Feathers variety act, composed of three Cornell students, which appeared on Ted Mack's television show.

The future holds much in store for Tom. In his remaining year before graduation, he plans to spend a good part of his time in a host of activities. Next year, for in-

(Continued on page 64)

This is a magnification of what abrasive material?

- ☐ *Commercial Diamond*
- ☐ *Fused Silicon Carbide*
- ☐ *Fused Aluminum Oxide*
- ☐ *Boron Carbide*

The answer "Fused Aluminum Oxide" gives you a passing mark. But, it's not just ordinary fused alumina. It's Norton 32 ALUNDUM* abrasive in a single crystal, containing more than 99% pure fused alumina — hailed as the "greatest abrasive contribution to increased grinding production in more than 40 years."

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When bauxite is submitted to an extremely high temperature in an electric furnace by an ingenious Norton Process, grains of 32 ALUNDUM abrasive form in a fluid matrix where each grain grows into a single, complete crystal — strong in shape and with many sharp points on all sides. The matrix not only contributes to 32 ALUNDUM abrasive's unique crystalline structure but also absorbs impurities from the melt. This accounts for the better than 99% purity.

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The extra sharpness and crystalline form of Norton 32 ALUNDUM abrasive enables it to grind cast iron, aluminum, bronze, brass, soft steel, high-speed steel and cast alloy tool materials. Its versatility is further borne out by a typical report. In one prominent plant, Norton 32 ALUNDUM wheels, replacing other wheels, accounted for over-all time savings, floor to floor, of: surface grinding — 26.3%; internal grinding — 13.1%; tool grinding — 13.2%; cylindrical grinding — 25%.

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This example of "making better products to make other products better" promises an interesting future to young engineers who want to contribute to new developments. Norton Research is well worth investigating.

Free Folder

highlights the cost-cutting advantages of Norton 32 ALUNDUM abrasive on countless grinding jobs. Write for your copy.

Gordon R. Finlay, Ph.D., Cornell '42, examines a specimen with the Metallograph in the Physical Testing Laboratory at the Norton electric furnace plant in Chippawa, Canada.

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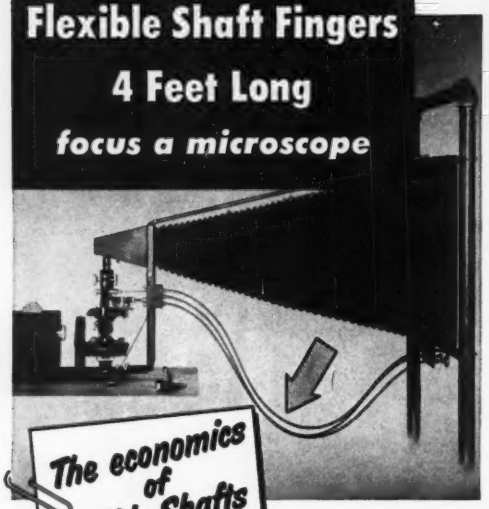
Flexible Shaft Fingers 4 Feet Long *focus a microscope*



The economics of Flexible Shafts

When the manufacturer of this microprojector wanted to provide a means of focusing the microscope from control knobs mounted 4 feet away, he used S.S.White flexible shafts. No other method offered the same simplicity and economy. As for sensitivity, the flexible shafts fully satisfied all requirements, because they are engineered and built to provide smooth, easy control over distances of 50 feet or more.

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Racket stringing by a factory-trained expert—a wide variety of nylons and guts—24 hours service.

Reasonable prices and our popular 10% trade dividend too.

◇ ◇ ◇

THE CORNELL CO-OP

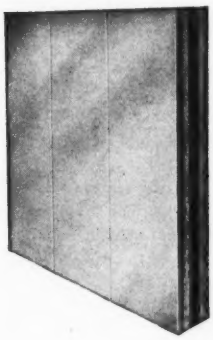
Barnes Hall — On The Campus

What's Happening at CRUCIBLE

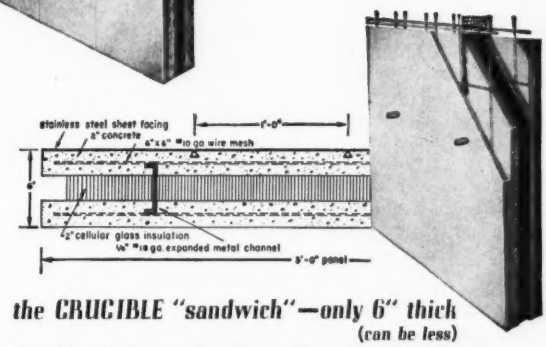
about stainless curtain walls

Modern construction methods have changed walls from the self-supporting type to a mere covering which does not support its own weight for more than one or two stories. Hence the definition of "curtain wall":—the facing or enclosure of the structural steel frame. This frame supports the entire weight of modern buildings.

The need has existed for a covering that would not only clothe the building, but be lightweight, economical and space saving. Because these requirements are more than adequately met with stainless steel curtain wall construction, this method is becoming increasingly popular with cost and space conscious owners, builders and architects.



the CRUCIBLE "sandwich"



the CRUCIBLE "sandwich"—only 6" thick ***(can be less)***

Crucible stainless steel curtain wall panels are in the form of 6-inch thick "sandwiches". The facing consists of flanged, light-gauge stainless steel sheets with a factory, or site-fabricated, sandwich consisting of cellular glass insulation between two layers of concrete with connecting reinforcing. Crucible 18-8 stainless as the outside face offers excellent resistance to weather and fire while providing eternal beauty with a minimum of maintenance; the inside face can be finished or painted to suit the requirements of modern building interiors. Since 18-8 is restricted in use, a good substitute material, type 430 stainless, now government decontrolled, offers the same benefits as 18-8 stainless.

moisture penetration

The unique characteristics of the cellular glass insulation stop moisture vapor migration from one face of the panel to the other. The cellular insulation properly designed and installed assures that condensation will not take place *anywhere* within the sandwich.

insulation

Although less than half as thick as the usual wall construction, this Crucible stainless steel panel construction has more than twice the insulating value. The "U" value (overall thermal conductivity) is approximately 0.15 BTU Hr./Sq.Ft./°F.

fire resistance

The Crucible sandwich met the requirements of a standard 4-hour fire test conducted in the testing laboratories of the National Bureau of Standards. This meets all old building codes and is double, or better, the requirements of modern enlightened building codes.

erection and fabrication

Since a building frame is not precision built, the attachment of the panel walls to the frame is done with fastening devices that provide necessary 3-dimensional adjustment. Panels can be made at the building site, and a 24-hour casting-to-fastening cycle is possible.

technical service available

Though the use of some stainless steel is now restricted, Crucible metallurgists and development personnel are continuing to investigate improved methods of curtain wall and other construction so that better buildings can be built when stainless is more freely available. For more information write: CRUCIBLE STEEL COMPANY OF AMERICA, General Sales and Operating Offices, Oliver Building, Pittsburgh, Penna.

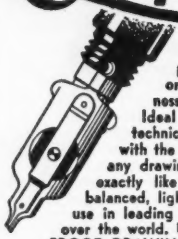
CRUCIBLE **first name in special purpose steels**

52 years of Fine steelmaking

Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa.
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

Draws a line 1/10th of a mile long with
1 FILLING!
WORLD'S ONLY DRAWING INK FOUNTAIN PEN
with interchangeable nibs

Pelican Graphos



Saves thousands of time-wasting pen filling operations for the artist or draftsman—insures uniform thickness of line from hairline to 3/8" thick. Ideal for lettering, freehand drawing, technical drawing, sketching, or stenciling with the interchangeable nibs. Graphos uses any drawing ink, black or colored. Handles exactly like any drawing pen — beautifully balanced, light touch. Time-tested—thousands in use in leading drafting rooms and art studios all over the world. Use the famous PELICAN WATERPROOF DRAWING INKS for best results.
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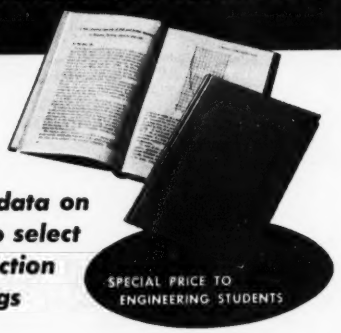
BE AN EXPERT ON BEARINGS



...latest data on how to select anti-friction bearings

SPECIAL PRICE TO ENGINEERING STUDENTS

Explains bearing types, designs, tolerances, load distribution, dynamic capacity, loads, selection, installation and maintenance, and applications. Includes dimension tables, conversion values, symbols and abbreviations.
Regular price of this 270-page book is $1.75. SKF's reduced the price to students to $1.25 in lots of 10 or more—$1.00 in lots of 20.
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SKF
BALL AND ROLLER BEARINGS

Retiring Board

(Continued from page 60)

stance, he will be co-chairman of the Campus Conference on Religion. After graduation, Tom plans to work on the business side of engineering rather than the technical. He simply enjoys working with people.

STAN COHEN CE '52

To most of us ink-stained engineers, it's really a pleasure to find one of our brethren who is able to draw neatly those endless pages of report diagrams. Such a fellow is Stan Cohen, of the ENGINEER Illustrations Board.

A graduate of Erasmus Hall High School in Brooklyn, Stan entered Princeton in 1943. In 1944, he went into the Army, becoming a Lieutenant in the paratroops. Stan served with the 82nd Airborne Division in Europe, and was discharged in 1947. That year, he attended Sampson College and the following year entered Cornell.

Here at Cornell, Stan has been completely self-supporting. He has put himself through college with the G.I. Bill and by working as a handy man at a sorority for three years. In addition, he has found time to be secretary of the American Society of Civil Engineers and a member of Tau Epsilon Phi fraternity.

Next year, Stan plans to work in the heavy construction field. A person with drives and talents such as his will certainly make a name for himself.

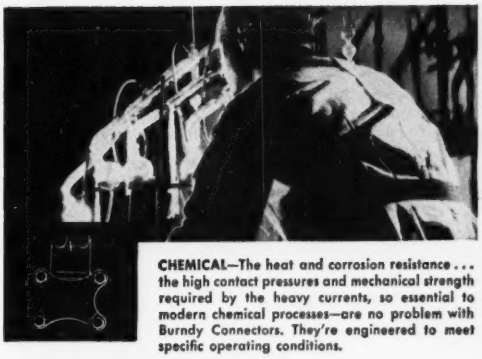
TED BLAKE ME '52

Ted Blake, retiring treasurer of the ENGINEER, graduated in 1946 from Lower Merion High School, Ardmore, Pa., and worked as a filling station attendant for a year before entering the Cornell Arts College. After a year and one half as a Chem. major, Ted transferred to ME, making up several courses in summer sessions. During the past few summers he has worked for Atlantic Refining Co. of Philadelphia and Carrier Air Conditioning Co. of Syracuse, his home city.

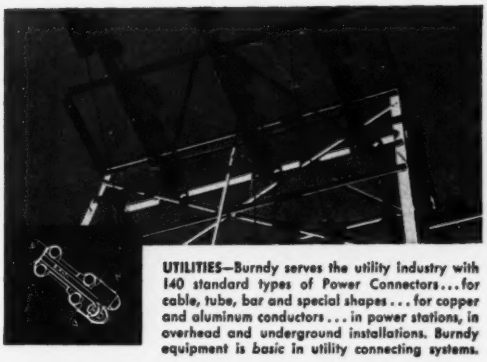
In his freshman year Ted rowed for the frosh crew team. He has served as Reporter, Rushing Chairman, and Secretary of his fraternity, Sigma Nu, and has also been instrumental in raising funds and services for Beebe Chapel of Ithaca. He is a member of Atmos Club, Savage Club, and Pi Delta Epsilon, journalism honorary. Ted's chief hobbies are music, golf, and swimming. A good clarinet player, he once considered taking up music as a career, but later decided against it. He still enjoys listening to and playing his clarinet to his favorite records by Benny Goodman.

When he graduates, Ted is going to Wright Field, Dayton, Ohio, where he will work in the Research and Development Department of the United States Air Force. After two years at Dayton, he would like to enter into the engineering sales division of a medium-sized company where he can combine his engineering know-how with his desire to get out and mix with people.

Wherever there's electricity... you'll find Burndy connectors on the job!

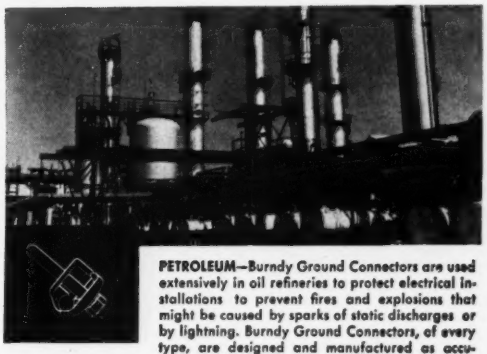


CHEMICAL—The heat and corrosion resistance... the high contact pressures and mechanical strength required by the heavy currents, so essential to modern chemical processes—are no problem with Burndy Connectors. They're engineered to meet specific operating conditions.



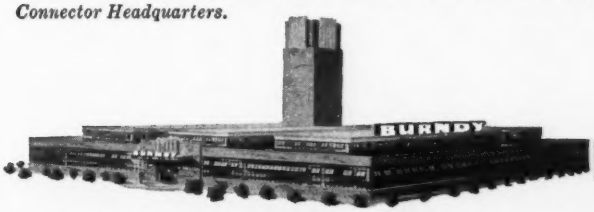
UTILITIES—Burndy serves the utility industry with 140 standard types of Power Connectors... for cable, tube, bar and special shapes... for copper and aluminum conductors... in power stations, in overhead and underground installations. Burndy equipment is basic in utility connecting systems.

MINING—Underground heavy-duty wiring systems must be protected against dampness, vibration, dust. Where a short circuit might cut off fresh air, stop the shaft elevators, throw out the lighting, interrupt pumping, or even cause an explosion—unfailing operation of the electrical installation is literally a matter of life or death. Leading engineers specify Burndy Connectors.



PETROLEUM—Burndy Ground Connectors are used extensively in oil refineries to protect electrical installations to prevent fires and explosions that might be caused by sparks of static discharges or by lightning. Burndy Ground Connectors, of every type, are designed and manufactured as accurately as those which are called on to carry current continuously.

Burndy Connectors are specified because of their superior performance in joining, terminating, clamping, and grounding every size and functional variety of electrical conductor—from the smallest home wiring circuit to the largest industrial installations. Burndy engineering is continuously developing more and more efficient connecting methods. *Engineering graduates and students are welcome visitors at Burndy Connector Headquarters.*



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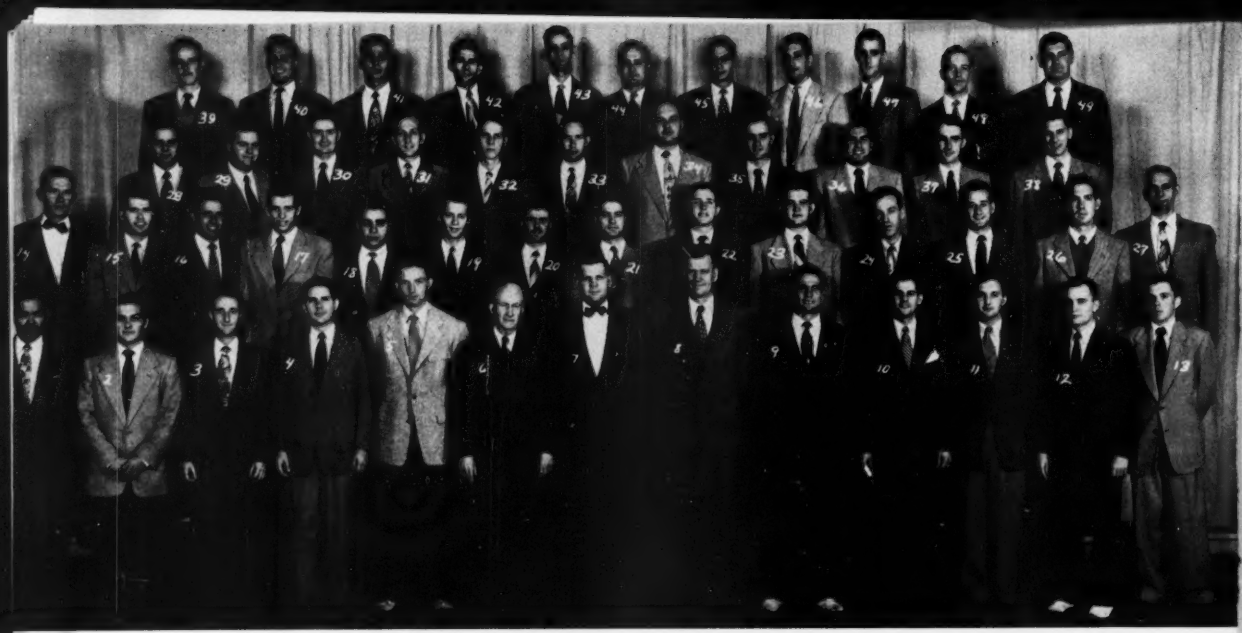
"WORLD'S LARGEST MANUFACTURER OF ELECTRICAL CONNECTORS"



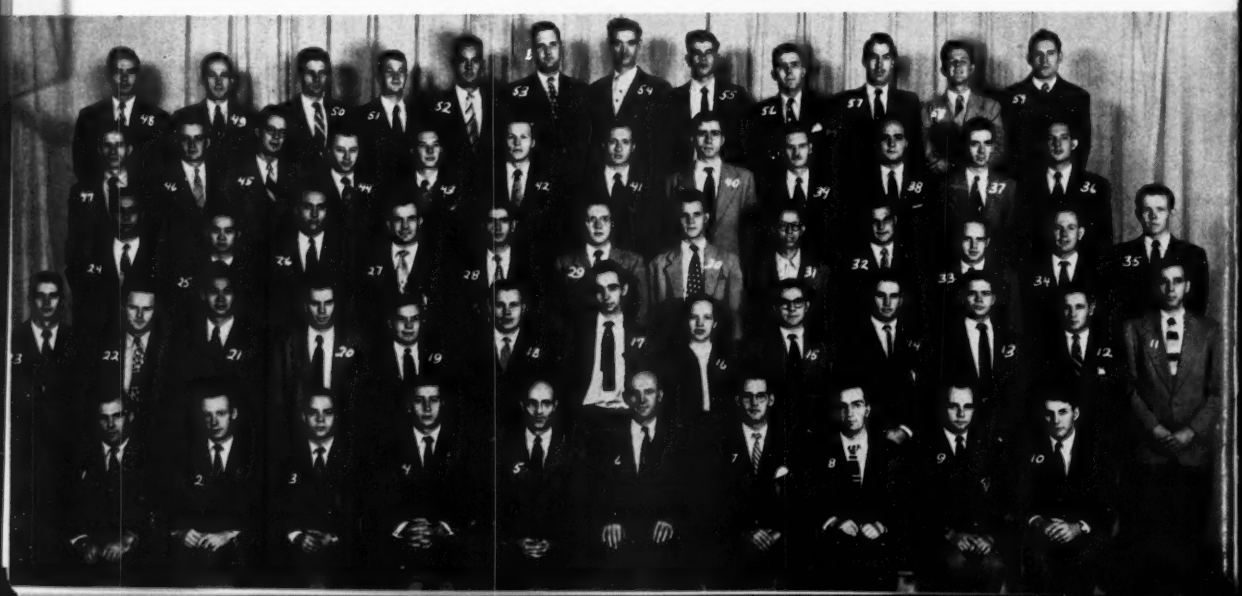
School of Civil Engineering

1. Shimabukuro, H. M.
2. Pellegrini, A. L.
3. Baumgarten, E. M.
4. Hower, D. J.
5. Chittenden, R. E.
6. Perry, J. E. (Prof.)
7. Fisher, G. P. (Prof.)
8. Christensen, N. A. Director
9. Bortko, W. S.
10. Cohen, S. P.
11. Ruckaberle, W. H.
12. Bergun, E. F.
13. Freer, R. K.
14. Robertson, F. P.
15. Russell, G. R.
16. Stylianopoulos, L. C.
17. Newhard, J. E.
18. Perrino, L. H.
19. Cadiz, D. G.
20. Johanning, J. M.
21. Wallace, R. E.
22. Bigelow, W. F.
23. Smith, F. K., Jr.
24. Taylor, D. S.
25. Hochberger, S.
26. Janes, E. S.
27. Morgan, J. M.
28. Weber, R. E.
29. Taussig, P. T.
30. Sowarby, J. C.
31. Rook, J.
32. Marson, W. A.
33. Trask, F. W.
34. Beaujon, J. R., Jr.
35. Singer, D. F.
36. Calderella, J. L., Jr.
37. Murphy, E. J., Jr.
38. Fitzner, R. E.
39. Haugaard, W. C.
40. Salvino, G. N.
41. DiStasio, J. R.
42. Lurie, J.
43. Jones, T. W.
44. McMahon, W. A.
45. Flom, E. L.
46. Huffman, F. M., Jr.
47. Nuttle, T. O.
48. O'Brien, J. J.
49. Casey, J. B.

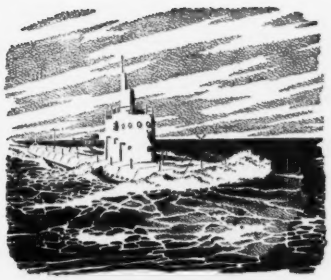
Class of 1952

School of Electrical Engineering

1. Andersen, J. J.
2. Doyle, W. C.
3. Pinkley, R. A.
4. Hanemann, H. A., Jr.
5. Kelly, M. J. (Prof.)
6. McIlroy, M. S. (Prof.)
7. Hamm, V. H.
8. Clark, D. W.
9. Lyon, W. J.
10. Bicknell, H. C., Jr.
11. McCarter, H. E.
12. Vogel, R. E.
13. Chamberlain, L. J.
14. Wilson, J. F.
15. Wiegand, D. A.
16. Diegert, M. A. (Mrs.)
17. McBride, L. E.
18. Lapkiewicz, A. J.
19. Weil, R. E.
20. McLaughlin, R. D.
21. Louis, J. Y.
22. Doggett, F. F.
23. Orbison, T. E., Jr.
24. Rosen, S. B.
25. Lee, T. Y.
26. Whiteley, G. C., Jr.
27. Chambers, G. R.
28. Berkley, L. N.
29. Pew, J. M.
30. Brawner, H. P., Jr.
31. Cohen, M. L.
32. Ferrante, J. J.
33. Collins, E. A.
34. Smith, C. H.
35. Robinson, J. G.
36. Loeper, D. S.
37. Noble, H. H.
38. Camasta, J. S.
39. Holden, W. D.
40. Gannett, G. L.
41. Berger, A.
42. Karcher, C. D.
43. Taylor, E. R.
44. Biracree, L. J.
45. Caffry, J. W.
46. Cox, H. D.
47. Marsh, F.
48. Ginty, A. L.
49. Campbell, C. F.
50. Lombardo, J. M.
51. Carlson, A. R.
52. Stone, W. E.
53. Messinger, E. W., Jr.
54. Diegert, M. B.
55. Beeskow, H., Jr.
56. Teegarden, W. M.
57. Simmons, C. D.
58. Pease, H. G.
59. Pincoffs, P. H.



How Honeywell Engineers help make it possible for a sub to dive swiftly and safely



It's a tense moment aboard a U. S. Navy submarine when the signal for diving stations electrifies the crew.

And to make sure all preparations have been *properly* made for a swift, safe descent—submarines are equipped with a panel of colored lights like the one shown below aboard the *U.S.S. Silversides*. Submariners call it the "Christmas Tree," because when all valves and hatches are closed the whole panel glows green.

Important to the "Christmas Tree" are tiny switches—that *must never fail*.

That's why, in choosing the hundreds of precision switches found in every submarine, the Navy selects dependable, proven MICRO Precision Switches, produced by Honeywell.

And this is only one of many vital functions Honeywell devices perform in the fields of marine controls, aviation, guided missiles and atomic energy.

Today, fabulous new controls for many fields are being developed by the men in our expanding engineering and research sections, who find their work often calls for fascinating study in the realm of pure science.

There's real opportunity for engineers at Honeywell—for this is the age of Automatic Control.

And Honeywell has been the *leader* in controls for more than 60 years!

America lives better—works better with Honeywell Controls

For information about opportunities in our engineering and research departments, write us, stating your qualifications. Depending on the location you prefer, send your letter to Personnel Dept., Minneapolis-Honeywell, Minneapolis 8, Minn.; Personnel Dept., Minneapolis-Honeywell, Brown Instruments Division, Philadelphia 44, Pa.; or Personnel Dept., Minneapolis-Honeywell, Micro Switch Division, Freeport, Ill.

MINNEAPOLIS **Honeywell**

First in Controls

STRESS and STRAIN...

A fat lady stepped on the scales, not knowing they were out of order. The indicator stopped at 75 pounds.

"Holy smokes," exclaimed a drunk who watched her, "she's hollow!"

* * *

A certain brewer sent a sample of his beer to a lab to be analyzed. A few days later he received a report from the chemist—
"Dear Sir:
Your horse has diabetes."

* * *

Stopping at the first house on his famous ride, Paul Revere cried, "Is your husband home?"

"Yes," came the answer.

"Then tell him to dress and fight the British."

At the second, third and fourth houses he repeated the conversation. As he rode by the fifth house he again repeated the cry.

"No," was the reply.

"Whoa!"

* * *

Coed: "I'll stand on my head or bust."
P.T. Instructor: "Just stand on your head. We don't ask too much."

* * *

Rules for Vet Barracks:
(1) No liquor allowed in rooms.
(2) Do not throw bottles out of the windows.

* * *

"So you had a date with an engineer?"

"No, I tore my dress on a nail."

* * *

They laughed when I came with shorts on, but when I sat down they split.

Prof: (After the final): "Well, what did you think of the course?"

M.E.: "I thought that it was all-inclusive; everything that wasn't covered during the semester was on the final exam."

* * *

Then there was the fellow who had a hobby of collecting stones and putting them in his bathroom.

He had rocks in his head.

* * *

Drunk: "What's that crawling up the wall?"
Bartender: "A lady bug."
Drunk: "Gad, what eyesight!"

* * *

Definition of a neurotic: a relatively stable individual with both feet planted firmly in mid-air.

* * *

Exhale, Mary Lou. No one's looking.

* * *

The difference between amnesia and magnesia is that the fellow with amnesia doesn't know where he's going.

* * *

The old engineer pulled his favorite engine up to the water tank and briefed the new fireman. The fireman got up on the tender and brought the spout down all right but somehow his foot caught in the chain and he stepped right into the tank.

As he floundered in the water, the engineer watched him with a jaundiced eye.

"Just fill the tank with water, Sonny," he drawled. "No need to stamp the stuff down."

He: "I suppose you dance."
She: "Oh, yes! I love to."
He: "Fine, that's better than dancing."

* * *

Prof:"That's five times this week you have failed to complete your assignment. Have you anything to say for yourself?"
Stude: "Thank God it's Friday."

* * *

Lady: "One fare for me and a half-fare for my little boy."

Conductor: "But he has on long pants."

Lady: "All right, full fare for the boy and half-fare for me."

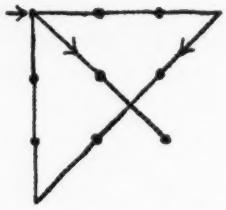
* * *

His wife lay on her death bed. She pleaded: "John, I want you to promise me that you'll ride in the same car with my mother at the funeral."
He sighed: "O.K., but it's going to ruin my whole day."

* * *

"That's quite some strapless evening gown you've got on. What keeps it up?"
"A city ordinance."

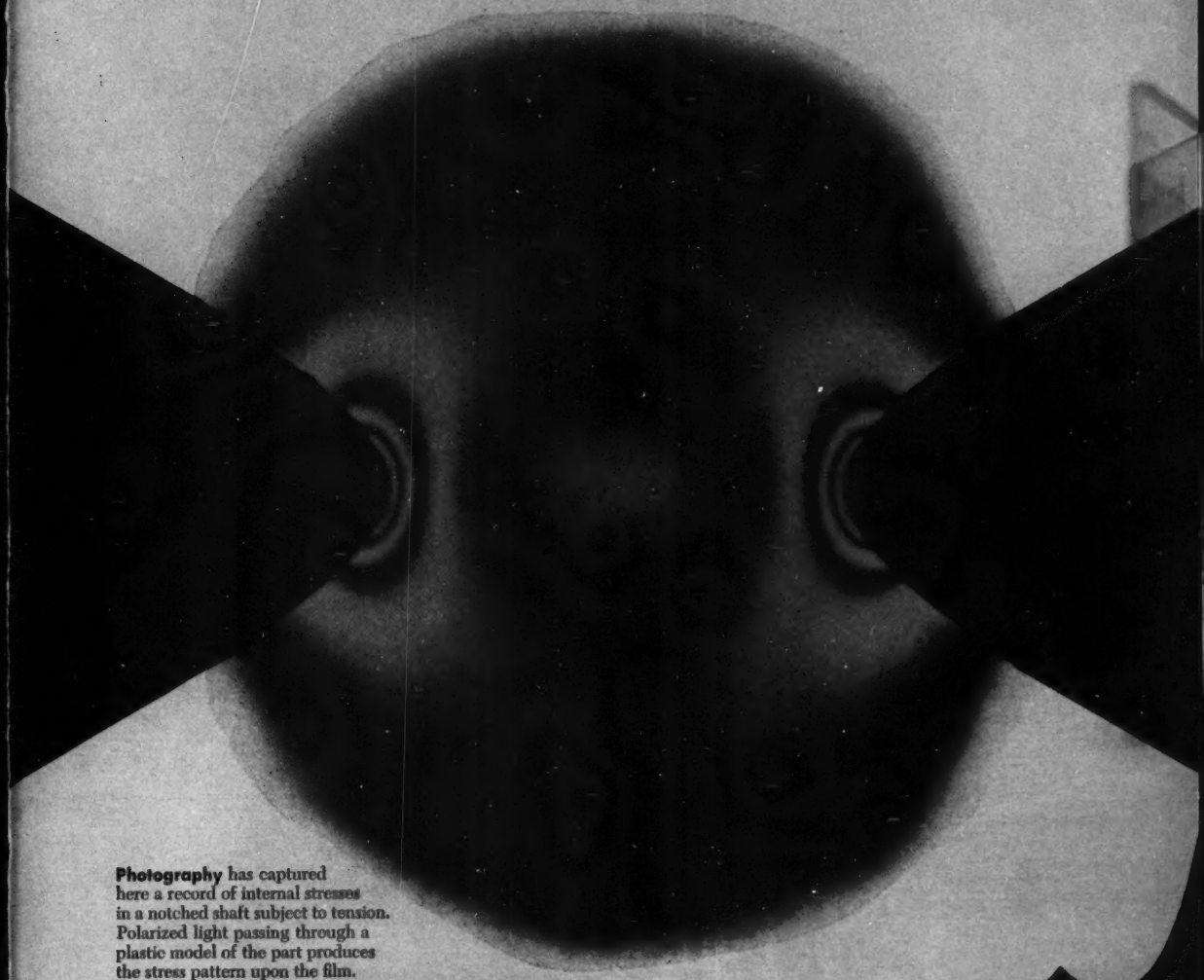
Answer to last month's Brain Teaser.



Photography gives engineers quick, accurate facts

● In routine work—in unique applications—engineers find photography can supply information obtainable in no other way. It can show you internal stresses in machine parts—you see what modifications in design will increase strength and reduce weight. You can study fast motion by slowing it down with high speed movies. You can record the flick of the cathode-ray trace or get accurate records of other instrument readings.

Photography is already aiding engineering in many important ways, and new applications are being made every day. This has led graduates in the physical sciences and in engineering to find positions with the Eastman Kodak Company. If you are interested, write to the Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, N. Y.



Photography has captured here a record of internal stresses in a notched shaft subject to tension. Polarized light passing through a plastic model of the part produces the stress pattern upon the film.

FUNCTIONAL PHOTOGRAPHY

. . . serves industrial, commercial and scientific progress

Kodak

WE ASKED GRADUATES TEN YEARS OUT OF COLLEGE:

WHAT MADE YOU DECIDE ON A CAREER WITH GENERAL ELECTRIC?

This advertisement was written by G-E employees who graduated ten years ago—long enough to have gained perspective, but not too long to have forgotten the details of their coming with the Company. These graduates were sent a questionnaire and were requested to return it unsigned. Their answers, listed below in order of mentions, give an informative appraisal of G.E. as a place to work and as a source of career opportunities.

1. G-E TRAINING PROGRAMS

Sample quotes: "I knew that G.E. offered the best training courses." "Liked the idea of rotating assignments and courses." "Wanted to take advantage of the training courses." "G.E. had a training plan which would let me choose a job after reasonable time for investigating jobs available in the Company." "I felt that Test (Test Engineering Program) would make the easiest transition from school to work." "I felt that I would get the best kind of electrical engineering training if I went with G.E." "The Test course appealed to me because of its combination of continued technical instruction plus practical experience on the test floor."

2. VARIETY OF OPPORTUNITIES

"Why does a youngster run away with a circus?" "Believed it was a good chance to find the field I liked best as I wasn't quite *sure* what type of work I wanted to get into." "G.E. goes out of its way to find the corner you are happiest in and best suited for." "The varied opportunities of work let you change jobs without leaving the company." "Only company which offered a job where an engineer could be in on design, sales and application—i.e., 'application engineering.'" "Promise of varied experience made it unnecessary to decide on a particular specialty until I had more opportunity to look the field over."

3. GENERAL ELECTRIC'S REPUTATION

"G.E.'s prestige and reputation appealed to me." "G.E. was more favorably disposed to the coming war effort and was doing work directly contributory." "High caliber persons with whom to work." "Reputation for technical excellence." "G.E.'s reputation as a good employer." "Because with the name of G.E. went a sense of security." "I felt that G.E. was the leader in the electrical field and I wanted to take part."

4. CONSIDERATE TREATMENT

"The only offer I received was from General Electric—other companies interviewed would not consider me because of my reserve officer status." "Among the companies offering jobs to college graduates in 1941, G.E. seemed to take more of a personal interest in its new men." "The G-E representatives made me feel they were interested in *me*."

For a free booklet, "Planning Your Career," a description of such G-E training programs as the Test Engineering Program, Business Training Course, Manufacturing Training Program, Chemical and Metallurgical Program, the Physics Program and Sales Training programs, write to General Electric Co., Dept. 221B-6, Schenectady, N. Y.

You can put your confidence in—

GENERAL ELECTRIC